POWER

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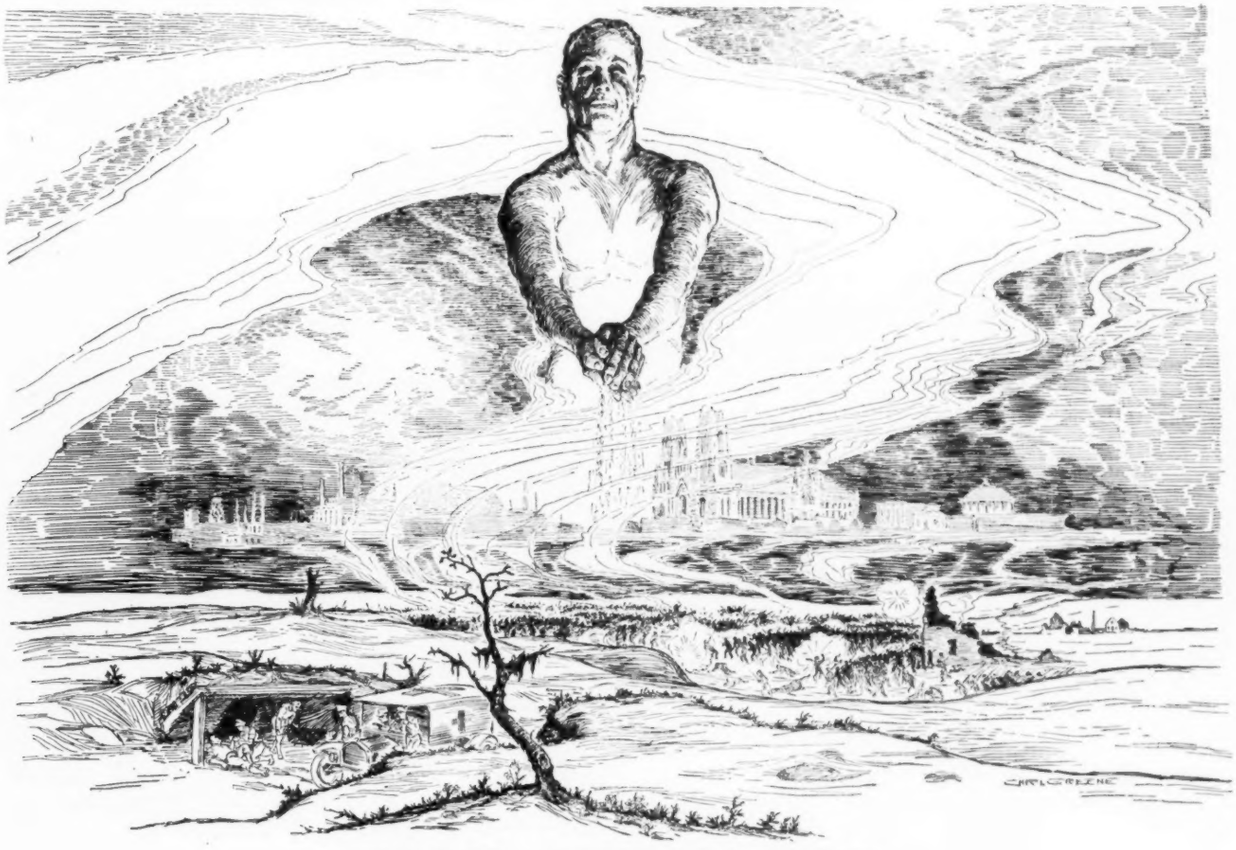


THE MASTER

RED WAR rules much of the world today. Artillery crashes and booms, machine guns crackle and clatter, rifles rip and snarl, shrapnel bursts and scatters and shells explode—all to kill and maim and destroy.

And from the rear, trains and motors bring fresh shells and bullets, more guns, more powder and more men to destroy and be destroyed, and return to the rear with the wounded and dead.

And it is I who have fashioned the shells and the guns, the rifles and the motors, the aeroplanes that scout above the armies, the trains that bring them, the barbed-wire entanglements that protect them.

And as I made these engines of destruction, so have I, directly or indirectly, fashioned the implements of mercy, the surgeons' knives, the ambulances, the blessed anaesthetic, and the spades which consign men, if science cannot conquer death, to the shallow graves.

And when this evil madness of conflict is passed and the work of reconstruction is begun, when men once more turn their energies to building and not to destroying, to life instead of death, I shall fashion the tools and the implements by which they do their task.

I shall make them new plows and new reapers, new trowels and new hammers, new chisels and saws. By magic of my great power what has been razed by war shall rise in new beauty of stone and steel. I shall help to restore old cathedrals and bridges and build new temples and palaces and railroads and factories where the heavy feet of Mars have crushed the old.

Without me war as we know it now might not be, but without me life as we know it now, in its beauty and scope and wonder, might not be. Without me siege guns might not batter to bits forts believed impregnable, but without me the mightiest achievements of peace would be as naught and the process of reconstruction after war would be ten thousand times as difficult.

I am the humble servant of man, yet the real master of the modern world. I am wealth, I am power, I am progress, I am the controlling influence of civilization.

I am Mechanical Power!

Contributed by Berton Braley, New York City.

Electrically Driven Paper Mill

By Thomas Wilson

SYNOPSIS—A comparison of two paper-mill plants, one employing Corliss engines connected to lineshafts by belt or rope drives and the other employing turbo-generators with individual motor drives. Although the latter was installed at larger cost, it insures greater flexibility and provision against shutdown. The mill is clear and open. The upkeep should be less and the economy higher than in the mechanical plant, although the latter is well-balanced and consequently more efficient than usual.

Back in 1904 the American Paper Box Co., of Grand Rapids, Mich., began the manufacture of folding paper boxes. Five years later the American Box Board Co. came into existence and built the first box-board mill in the city to supply the box factory with the required board. Having secured a site adjacent to the consumer of its product, the American Box Board Co. remodeled the old building, added new ones, and installed the necessary equipment for the manufacture of the board and a power plant. The factory equipment consisted of six 1,500-lb. beaters, four jordans, six duplex stock pumps and a 114-in. trim five-cylinder board machine, together with the necessary auxiliaries required in a plant of this size. In the power plant one 333-hp., two 250-hp. and one 150-hp. boiler were installed. For the engine room three units were selected: One 26x48-in. simple noncondensing Corliss, one 16x36-in. engine of the same type, and a 12x24-in. twin variable-speed engine. The 16x36-in. Corliss was installed to drive the constant line of the board machine, the twin engine the variable line of this machine, and the 26x48-in. Corliss was directly connected to the main beater lineshaft.

In 1910, or just a year later, the company having added a new department, the manufacture of corrugated paper boxes, it became evident that one board mill was not sufficient to take care of the requirements. It was not long before a reorganization was effected, and the American Box Board Co. absorbed the original American Paper Box Co., the American Corrugating Co. and the American Fiber Package Co., the last-named concern having been located at Battle Creek, Mich., and engaged in the manufacture of fiber shipping container cases. This amalgamation resulted in putting into operation in June of last year a second mill, electrically equipped throughout. The equipment consisted of eight 1,500-lb. beaters, four jordans, three duplex and one triplex stock pumps and one 114-in. trim five-cylinder board machine. A unique feature of this installation is that every individual machine is a unit in itself; that is, it is driven by an individual motor independently controlled and the amount of power in actual use is indicated by an ammeter on a panel board beside the motor.

The new mill called for the installation of a new power plant, which is operated independently of the older plant. It consists of three 400-hp. water-tube boilers and two 750-kv.-a. reaction turbines—one of the noncondensing type and the other a bleeder turbine provided with a condenser. From both plants the exhaust steam is utilized in the manufacturing processes. The older engine-driven plant is unusually well-balanced; that is, the supply of exhaust steam from the prime movers and auxiliaries very nearly equals the demand in the mill. In the turbine plant exhaust steam is drawn continuously from the noncondensing machine and any addition required is bled from the condensing machine. In this way all excess power requirements have the advantage of the vacuum and consequently a low water rate per unit of output.

The combined mills have an approximate capacity of 100 tons per day and are at present consuming their own output in the manufacture of folding paper boxes, corrugated shipping cases and fiber container cases.

The older plant is known as mill No. 1. The boiler room contains three vertical boilers—two rated at 250 hp. and one at 333 hp.—and one 150-hp. Stirling boiler. The three larger units have inclined-grate stokers and the other

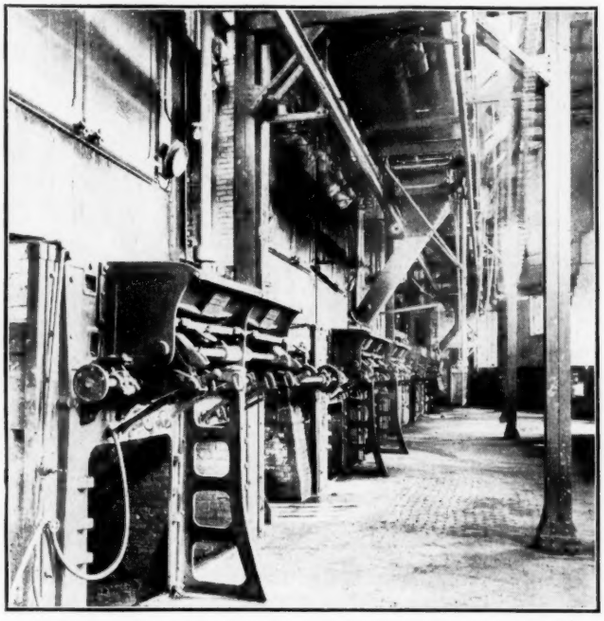


FIG. 1. BOILER ROOM OF THE NEW PLANT

a top-feed stoker. Each boiler has its usual quota of 10 sq.ft. of heating surface per horsepower, and the ratio of heating surface to grate area in each case is 50 to 1. The boilers operate at 150 lb. pressure with no superheat. Natural draft is supplied by a reinforced-concrete stack 78 in. diameter and 175 ft. high. An offset 90 ft. from the base allows for a double wall. Apertures around the circumference, top and bottom, lead to the space between these walls and provide for air circulation. The stack was built six years ago when this construction was in vogue.

A uniform steel breeching 4x8 ft. in section serves the boilers. Its construction is unusual. One-inch angle irons with the apexes out are laid next to the metal walls and over these 2-in. asbestos blocks covered with painted canvas. The breeching is U-shaped, the boilers discharging into one leg, and in the other is an economizer containing 24 sections 10 tubes wide. A bypass joining the two legs provides for direct passage of the gases to the stack. The economizer is also covered with 2-in. asbestos

blocks and on the top above the asbestos is one course of brick laid flat and loose. Entering the economizer the draft is 0.75 in., at the base of the stack it is 1⅛ in., and over the fire 0.25 in. The gases leave the boilers at an average temperature of 600 deg. The average temperatures of water entering and leaving the economizer are 200 and 300 deg. F. respectively. Continuous records of these data are taken by recording thermometers.

Feed water is supplied by a triplex 5½x8-in. pump belt-driven from one of the Corliss engines, or by an outside center-packed 12&7x12-in. steam pump. The power pump is generally used. On either the suction is 6 ft. below the feed-water heater, which is of the open type and rated at 1,500 hp. Between the pumps and the economizer the feed to the boilers is measured by a venturi meter. Feed-water regulators control the supply to the boilers. West Virginia slack averaging 13,500 B.t.u. and 12 per cent. refuse is used as fuel. The average evaporation per pound of coal as fired is 9 lb. of water from and at 212 deg. F.

As previously stated, there are three engines in the plant driving mill No. 1. The largest is a 26x48-in. non-condensing Corliss engine operating at 85 r.p.m. and on a steam pressure of 150 lb. It is connected to a lineshaft 145 ft. long, which drives by belt six beaters, eight agitators and a 6-ft. fan for heating and ventilating the beater room. A rope drive also connects four jordans with this shaft. The connected load runs close to 900 hp., and the average load will vary from 700 to the maximum connected horsepower.

The 16x36-in. Corliss having a constant speed of 100 r.p.m. transmits its power through a rope drive to a line-shaft in the basement. The rope drive is of the American type having 16 strands of 1¼-in. rope. This shaft drives seven stock pumps, five fan pumps, five screens, a centrifugal pump to supply water for manufacturing purposes, four agitators, a 160-in. fan for ventilating the paper-machine room and one save-all, which recovers 5 per cent. of the stock from the waste drainage going to the sewer. The engine is rated at 250 hp., and the average load is close to 130 hp. The 12x24-in. twin nonreleasing Corliss drives the variable line of the paper machine. Through a special speed-changing device the engine speed may be varied from 35 to 175 r.p.m.

All the engines operate at a back pressure of about 5 lb. Most of the exhaust steam is utilized summer and winter, and in the coldest periods of the year it is necessary to supplement it with a little live steam. In the drying cylinders of the paper machine there is always a large demand for steam. In winter the buildings must be heated, and part of the exhaust is used in the feed-water heater.

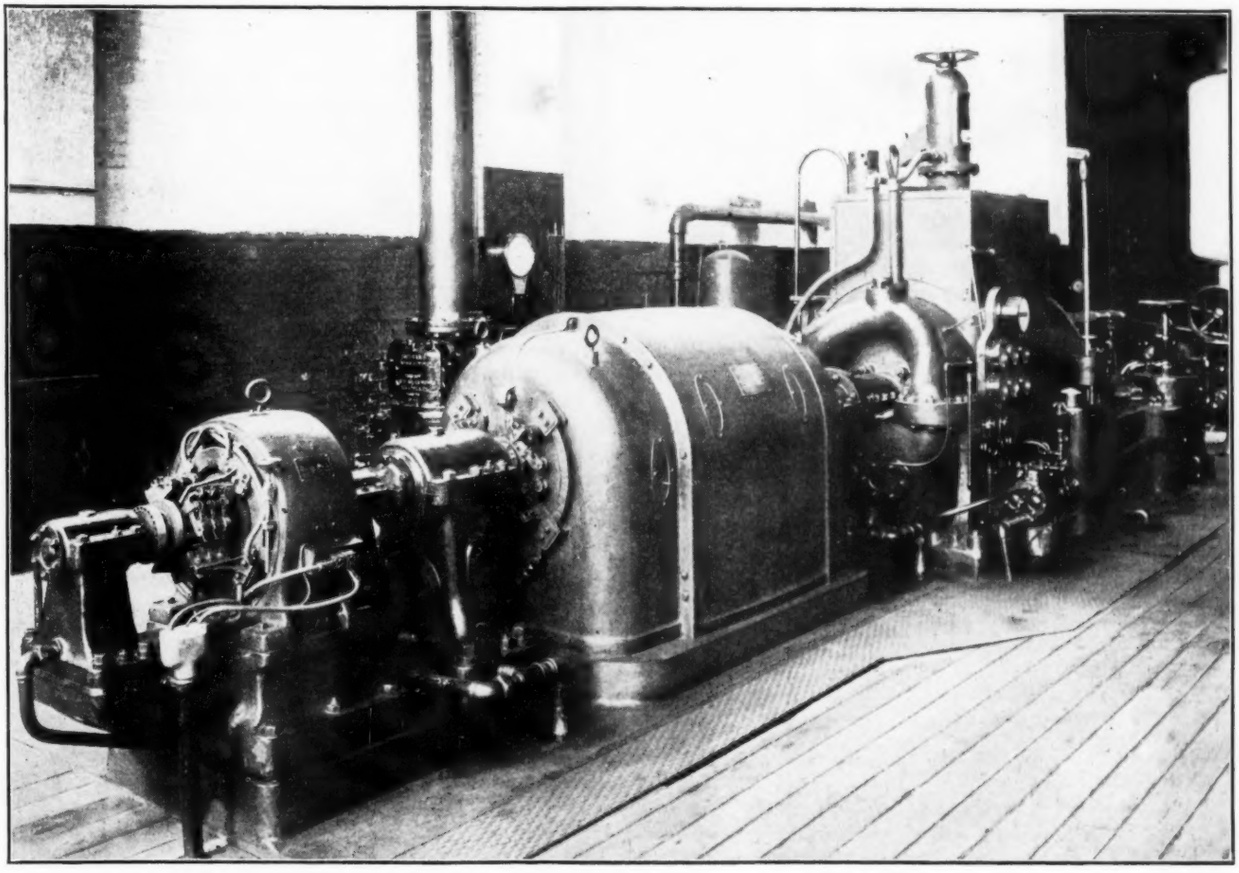


FIG. 2. CONDENSING TURBINE OF 750-KV.-A. CAPACITY. ONE OF THE TWO TURBINE UNITS

The condensation from the mill is pumped back to the open heater previously mentioned. Makeup for the boiler feed comes from the clear water tank of a water softener having a capacity of 35,000 lb. per hr. The river water used in the plant contains about 20 grains of incrusting solids per gallon. In the softening process this is reduced to 6 to 8 grains per gallon.

The new boiler plant was installed during the winter of 1913 and was ready for operation in June. It contains three 400-hp. horizontal four-pass water-tube boilers built for a pressure of 200 lb. The boilers have inclined-

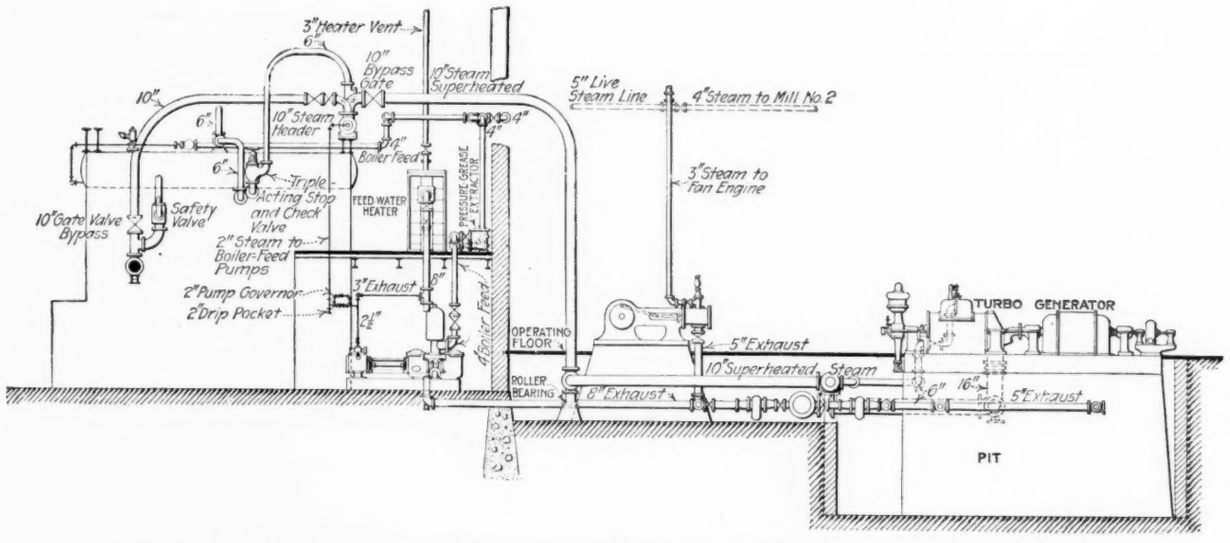


FIG. 3. ELEVATION THROUGH BOILER AND TURBINE ROOMS, SHOWING GENERAL PIPING

grate stokers whose areas bear a ratio to the heating surface of 1 to 50. Superheaters raise the temperature of the steam 125 deg. An economizer containing 36 sections 10 tubes wide serves the three units, while mechanical draft is supplied by an engine-driven fan, the engine being of the throttling type controlled by a pressure regulator. The stack is steel, 78 in. diameter and 100 ft. high. Over the fire 0.25 to 0.35 in. of draft is available, and at the fan inlet it will average 1 in., although 2½ in. might be obtained if it were necessary.

In this case the breeching is made of brick. It is of rectangular section, 7x9 ft. From the boilers to the fans the breeching doubles back on itself, the economizer being in the top leg. The feed water from the heater enters the economizer at an average temperature of 214 deg. and leaves at 310 deg. The flue gases leave the boilers at about 500 deg. The heater, which is of the open type, is rated at 2,500 hp. It is 12 ft. above the pumps, which are of the outside center-pack type operating against a pressure of 225 lb. A venturi meter measures the supply to the boilers, which is controlled by feed-water regulators.

Each boiler is equipped with triple-acting stop-check valves, high- and low-water columns and all of the usual apparatus found in a modern plant. The boilers are set 11 ft. from the floor line to the bottom of the front tube header. From the fourth pass the gases leave under the rear water leg. From the same kind of coal used

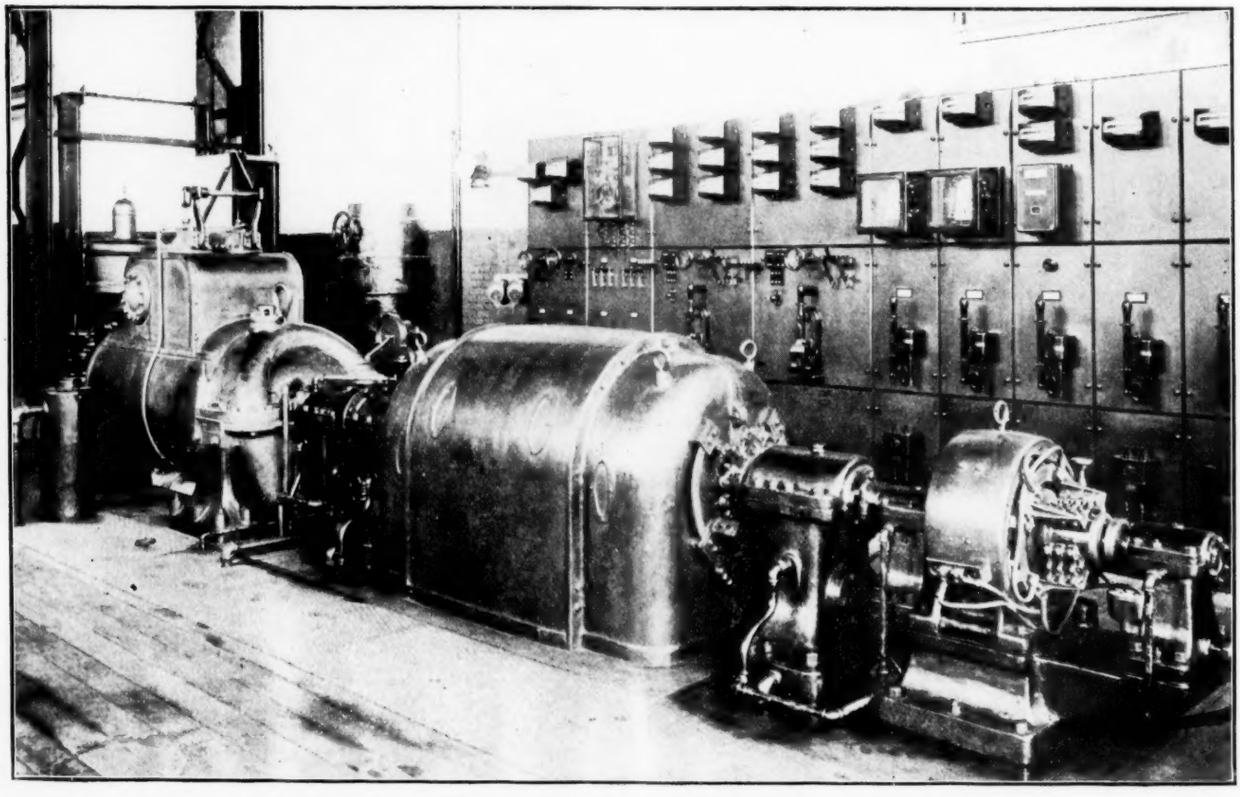


FIG. 4. NONCONDENSING TURBINE AND SWITCHBOARD AT THE REAR

in the older plant an average evaporation of 10 lb. of water from and at 212 deg. F. is obtained. All of the high-pressure piping has reinforced van stone joints with metallic gaskets. The fittings are of steel of the 300-lb. American standard. The valves are also of steel and of the outside stem and yoke type lined with monel metal.

From a railway siding along the boiler room the coal is dropped from the cars into a track hopper. By an apron feeder it is transferred to a bucket elevator, and at the top of the bunker is delivered to a screw conveyor. The latter is 126 ft. long and distributes the coal into any part of the 300-ton overhead bunker. From the bunker the coal is delivered into either one of two hand-operated traveling weigh hoppers of 1,500 lb. capacity, the exact weight being obtained from a type registering scale beam. The conveying equipment is driven by a 20-hp. motor or engine of the same rating, the capacity of the equipment being 35 tons per hour. The ashes are wheeled out onto the premises and sold at a charge of 25c. per load. Fig. 1 shows the boilers.

As previously stated, the two turbines, Figs. 2 and 4, are each rated at 750 kv.-a. One is of the straight noncondensing type, while the other is designed for condensing operation with provision to bleed a portion of the steam at 5 lb. pressure

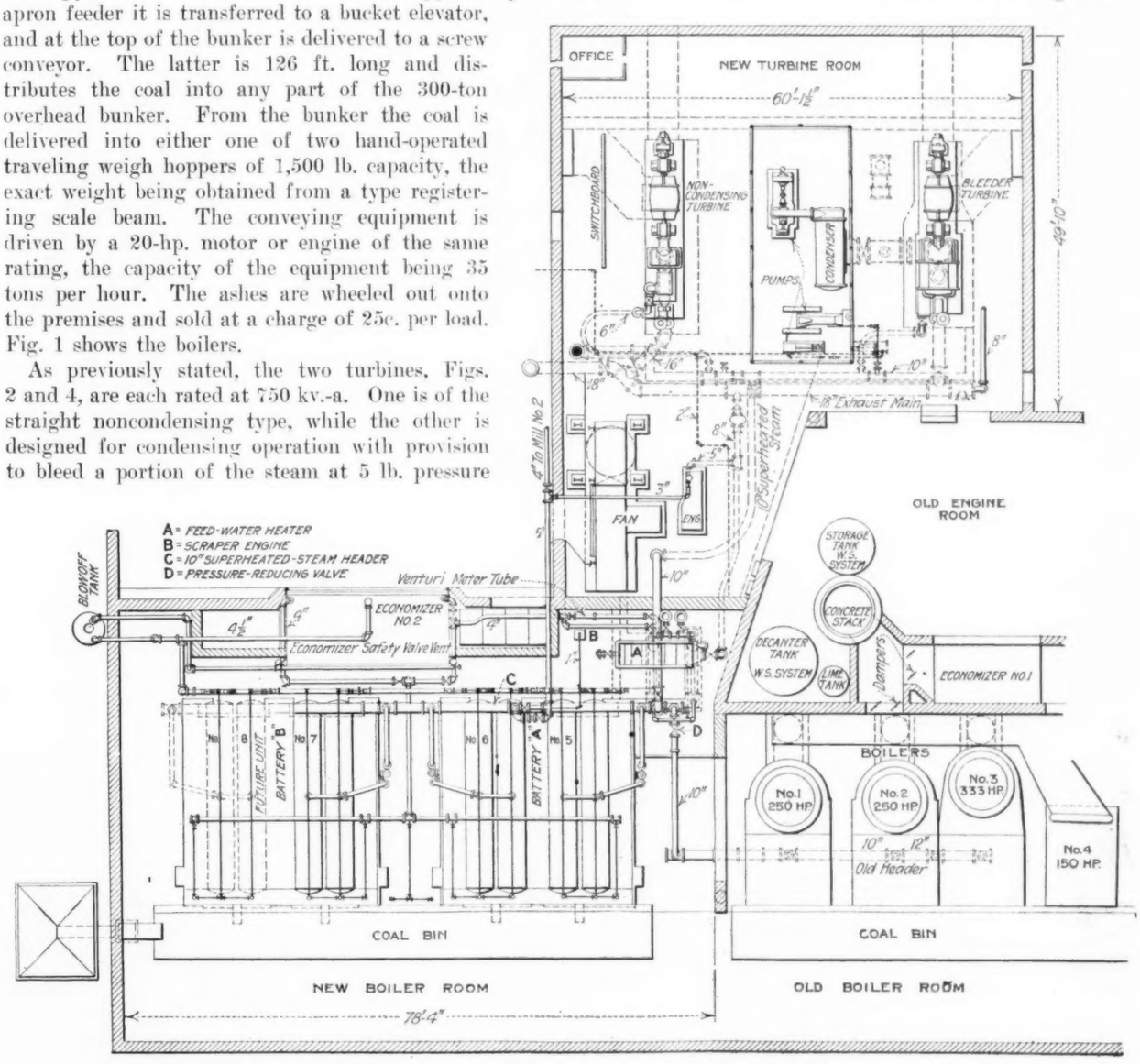


FIG. 5. PLAN VIEW OF POWER PLANTS, SHOWING GENERAL LAYOUT OF THE MACHINERY

into the exhaust mains. Both turbines have a speed of 3,600 r.p.m. and are coupled to three-phase 60-cycle generators delivering current at 440 volts. The exciters are on the generator shaft. Air for cooling the generators is taken from the roof through galvanized-iron ducts and discharged outside of the turbine room.

The condenser is of the surface type with 1,656 sq.ft. of surface, or 2.6 sq.ft. per kilowatt of generator rating at 80 per cent. power factor. The circulating pump, which is a single-stage centrifugal having a capacity of 1,900 gal. per min., is turbine-driven and on the same shaft is a 2-in. centrifugal condensate pump which discharges to a tank 30 ft. above the turbine-room floor. This tank furnishes soft water for sealing the turbine glands, but most of its contents flow by gravity to the open feed-water heater. A dry-vacuum pump of the crank-and-flywheel type removes the air from the condenser.

Circulating water is pumped from the river, which is about 400 ft. distant from the plant. It is passed through twin strainers and from the condenser is discharged into sand filters in the paper mill and there used for manufacturing purposes.

A load of about 1,000 kw. is carried by the two turbines. In winter, when more exhaust steam is required, a greater part of the load is carried on the noncondensing machine. During the warmer months the operation is reversed. The noncondensing turbine carries just enough load to supply, with the help of pumps and auxiliaries, the demand for exhaust steam. The greater part of the load is carried on the bleeder turbine, and it is run straight-condensing.

According to the guarantee the steam consumption on the noncondensing turbine at full load is 36.3 lb. per

kw.-hr. The bleeder turbine has a guaranteed rate of 17.3 lb. per kw.-hr. when operating straight-condensing at full load, and 30 lb. per kw-hr. when bleeding 10,000 lb. of steam per hour at 5 lb. pressure into the exhaust main. The back pressure on the noncondensing turbine also averages about 5 lb. as it exhausts into the same system of mains. The returns from the mill are brought back to the feed-water heater by vacuum pumps located in the condenser pit. Current is generated at 440 volts and at this pressure is delivered to the motors. For lighting it is transformed down to 110 volts.

Besides the exciters on the main generator shafts, the plant is provided with an independent 25-kw. direct-current machine driven by a turbine through a reduction gear having a ratio of 3 to 1. The speed of the turbine is 5,400 r.p.m. and that of the generator 1,800 r.p.m. This machine may be used as an exciter when starting up the plant or in case of accident to the other exciters. It is also used for charging the batteries in electric trucks and for Sunday and night lighting in the mill. Figs. 3 and 5 show elevation and plan view respectively of the power plants.

An interesting addition to the equipment of the plant is a synchronous-motor-generator set installed to supply direct current for the motor driving the paper machine, Figs. 6, 7 and 8. The latter machine, rated at 100 hp. is under push-button control and has a range in speed of from 237 to 950 r.p.m. The synchronous motor of the set is rated at 300 kv.-a., while the generator is a 100-kw. 250-volt machine. The motor was made considerably larger so that its fields might be over-excited to advance the power factor and counteract the lag in current caused by the other motors in the mills, which are all of the induction type and mostly slow-speed machines. The 6½-kw. exciter is mounted on the shaft of the motor-generator set. This machine not only excites

PRINCIPAL EQUIPMENT OF POWER PLANTS OF AMERICAN BOX BOARD CO.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Boilers	Vertical water-tube	250-hp	Generate steam	150-lb. press., natural draft, stokers	Wickes Boiler Co.
1	Boiler	Vertical water-tube	333-hp	Generate steam	150-lb. press., natural draft, stokers	Wickes Boiler Co.
1	Boiler	Stirling	150-hp	Generate steam	150-lb. press., natural draft, stokers	Babcock & Wilcox Co.
3	Stokers	Roney	50 and 67 sq.ft.	Serve Wickes boilers	Driven by Westinghouse engine	Westinghouse Machine Co.
1	Stoker	Top feed	30 sq.ft.	Serve Stirling boiler	Driven by Detroit engine	Detroit Stoker Co.
1	Stack	Reinforced-concrete	78-in. x 175-ft.	Serve above four boilers		Metal Concrete Chimney Co.
1	Pump	Triplex	5½x8-in.	Boiler-feed water	Belted to Corliss engine	The Deming Co.
1	Pump	Simplex	12x7x12-in.	Boiler-feed water	150-lb. steam press.	Union Steam Pump Co.
1	Heater	Open	1,500-hp.	Heat feed water	Exhaust steam, temp. water, 200 deg.	Central Boiler Works
1	Grease extractor	Twin	No. 3	Remove oil from feed water		James Beggs & Co.
1	Meter	Venturi	1-in. orifice	Measure feed water		Builders Iron Foundry
4	Regulators	Pressure		Control feed to boilers		Murray Specialty Mfg. Co.
1	Economizer		24 sections, 10 tubes wide	Heat feed water	Entering gases 600 deg., water leaving 300 deg.	Green Fuel Economizer Co.
3	Gages	Recording		Temperature of flue gases and feed water		Bristol Co.
1	Engine	Simple Corliss	26x48-in.	Drives main beater lineshaft	150 lb. initial press., 5-lb. b.p., 85 r.p.m.	Nordberg Mfg. Co.
1	Engine	Simple Corliss	16x36-in.	Drives constant line of board machine	Constant speed 100 r.p.m., rope drive	Nordberg Mfg. Co.
1	Rope drive	American	16 strands, 1¼-in. rope	Drives constant line of board machine		Dodge Mfg. Co.
1	Fan		160-in. diam.	Ventilate paper machine room	Driven from lineshaft	Green Fuel Economizer Co.
1	Engine	Twin nonreleasing Corliss	12x24-in.	Drives variable line of board machine	35 to 175 r.p.m.	Nordberg Mfg. Co.
2	Pumps	Vacuum	8x10x12-in.	Returns from mill to heater		Union Steam Pump Co.
1	Water softener		35,000 lb. per hr.	Soften feed water	River water reduced from 20 to 6 gr. per gal.	Dodge Mfg. Co.
			NEW POWER PLANT			
3	Boilers	Hor. water-tube	400-hp	Generate steam	200 lb. press., 125 deg. superheat	E. Keeler Co.
3	Superheaters	Standard return-tube		Superheat steam	125 deg. superheat	Power Specialty Co.
3	Stokers	Roney	80 sq.ft.	Serve boilers		Westinghouse Machine Co.
1	Fan		13 ft., 6 in. diam.	Draft for boilers	Driven by Ball 11x16-in. engine controlled by Watts press. reg.	Green Fuel Economizer Co.
1	Economizer		36 sections, 10 tubes wide	Heat feed water	Entering gases 500 deg., water leaving 310 deg.	Green Fuel Economizer Co.
1	Heater	Open IXL	2,500-hp.	Heat feed water	Exhaust steam, water 214 deg.	T. J. Cookson
2	Pumps	Simplex	16x9x14-in.	Feed water	Pump against 225 lb.	Union Steam Pump Co.
2	Filters	Twin	No. 4	Filter feed water		James Beggs & Co.
1	Meter	Venturi	1½-in. orifice	Measure feed water		Builders Iron Foundry
2	Regulators	S. C.		Regulate water to boilers		S. C. Regulator Co.
2	Coal-handling system	Apron feeder, bucket elevator and screw conveyor	35-tons per hr.	Coal from track to bunker	Driven by 20-hp. Westinghouse motor and engine	Jeffrey Mfg. Co.
2	Weigh hoppers	Traveling	1,500-lb.	Weigh coal to boilers	Type registering scale beams	Fairbanks Morse & Co.
1	Turbine	Noncondensing	750-kv.-a.	Main generating unit	200 lb. steam, 125 deg. superheat, 3,600 r.p.m.	Westinghouse Machine Co.
1	Generator	Three-phase, 60-cycle, 440-volt	750-kv.-a.	Main generating unit	3,600 r.p.m.	Westinghouse Electric & Mfg. Co.
1	Exciter		18-kw.	Excite main generator	Mounted on generator shaft	Westinghouse Electric & Mfg. Co.
1	Turbine	Bleeder-type	750-kv.-a.	Main generating unit	200 lb. steam, 125 deg. superheat, 3,600 r.p.m.	Westinghouse Machine Co.
1	Generator	Three-phase, 60-cycle, 440-volt	750-kv.-a.	Main generating unit	3,600 r.p.m.	Westinghouse Electric & Mfg. Co.
1	Exciter		18-kw.	Excite main generator	Mounted on generator shaft	Westinghouse Electric & Mfg. Co.
1	Condenser	Surface	1,656-sq.ft.	Serve turbo-generator		Alberger Pump & Condenser Co.
1	Pump	Single-stage centrifugal	10-in. 1,900-gal. per min.	Circulating pump	Driven by 65-hp. Curtis turbine, 1,760 r.p.m.	Alberger Pump & Condenser Co.
1	Pump	Centrifugal	2-in.	Condensate pump	On same shaft as circulating pump	Alberger Pump & Condenser Co.
1	Pump	Crank-and-flywheel	6x14x10-in.	Dry-vacuum pump		Alberger Pump & Condenser Co.
1	Strainer	Twin	10-in.	Strain circulating water		Elliott Co.
1	Pump	Returbo	6-in.	Water for paper mill	Driven by 35-hp. Westinghouse motor, 1,760 r.p.m.	Manistee Iron Works
3	Pumps	Vacuum	8x10x12-in.	Return condensation from mill to heater		Union Steam Pump Co.
1	Exciter	Turbine-driven	25-kw.	Auxiliary exciter	Westinghouse turbine and reduction gear, 5,400 to 1,800 r.p.m.	Westinghouse Electric & Mfg. Co.
1	Motor generator	Syn. motor, d.-c. generator	Gen. 100-kw., motor 300-kv.-a.	Paper-machine set	6½-kw. exciter on same shaft, 900 r.p.m.	Westinghouse Electric & Mfg. Co.
1	Motor	D.-c.	100-hp.	Part of paper-machine set	Range speed 237 to 950 r.p.m.	Westinghouse Electric & Mfg. Co.

General Electric switchboard, Thompson instruments. Bristol indicating and recording gages. St. Johns steam meters. Golden-Anderson triple-acting stop-check valves. Wright Manufacturing Co. high- and low-water alarms. Pittsburgh Valve Foundry and Construction Co. valves. Westinghouse motors throughout the mill.

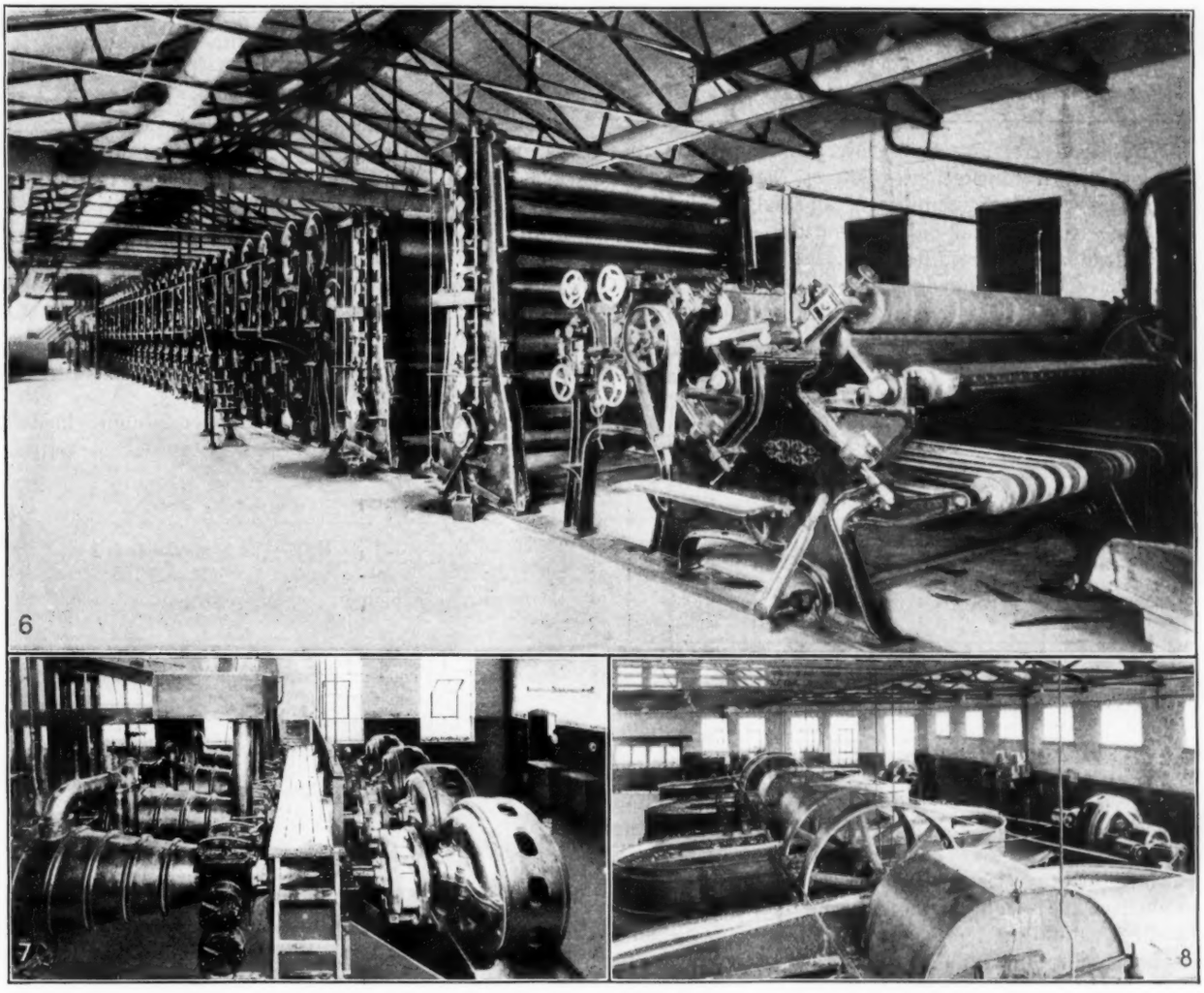
the synchronous motor and the generator of the set, but also the fields of the motor driving the paper machine, this being preferable to self-excitation due to the wide range in speed.

All the latest instruments are employed on a ten-panel black Monson slate switchboard. Two graphic kilowatt-hour meters record the energy delivered to the beaters and to the jordans. An integrating kilowatt-hour meter records the current to the paper-box department, and another of the same type totals all of the current. Hand-operated solenoid oil switches with automatic trips are employed, and a Tirrell voltage regulator controls the excitation.

Venturi meters indicate and record the amount of feed water to the boilers, and there are numerous recording and indicating gages for the initial steam and back pressures and the vacuum. There are also gages to record the draft at the fan inlet and meters to measure the low-pressure steam for heating and the paper-box division and the high-pressure steam for manufacturing purposes.

Both plants are operated 24 hr. per day on two shifts and six days per week. They are shut down Sunday morning at 6 o'clock and started at the same hour Monday morning. The capacity of the two mills is about 100 tons per day of 24 hr. In fuel about 60 tons of coal per day is required during the summer and in the colder months the daily coal consumption increases to about 75 tons.

Notwithstanding the friction in the lineshafts of the mechanical plant, the latter is so well-balanced in the amount of steam produced from the power requirements and the exhaust steam required in the manufacturing processes that highly economical results are obtained. Although no figures on the costs of operation are available, it is expected that the electrically driven mill, when it has been developed to the best working basis, will be more economical than the mechanical plant. It is much more flexible and has a greater factor of safety against shutdowns due to the individual motor drive. It is clear and open and free from the forest of belts required in the mechanical mill. As a consequence the expense for oil and belting will be greatly reduced and the upkeep should be considerably lower. With a full equipment of instruments it is possible to determine accurately the cost in power for each subdivision of the work, and an ammeter for each motor shows to what point each machine is loaded.



FIGS. 6 TO 8. VIEWS OF THE MOTOR-DRIVEN PAPER-MAKING MACHINERY

Fig. 6.—Paper machine driven by 100-hp. direct-current motor. Fig. 7—Jordans driven by individual induction motors Fig. 8—Double-ended motors driving the beaters

The company appears to be well-pleased with the results obtained and is of the opinion that the additional investment in the power-plant equipment was fully warranted.

The new power plant was designed by H. B. Prather, a consulting engineer, of Cleveland, Ohio. W. A. Jack is general manager of the company, F. H. Bither superintendent, and G. M. Taylor chief engineer.

Economical Load on Boilers

By Haylett O'Neill*

SYNOPSIS—Calculations and curves from numerous tests to show the most economical loads for boilers under different conditions.

With good stoking equipment, proper furnace materials and correct operating conditions, there is no longer doubt that a boiler of good design can safely produce several times the nominal builders' rating. Certain cases of overloading have resulted in marked economy, while others have been followed by needless waste. The following illustrates the merits of high and low output.

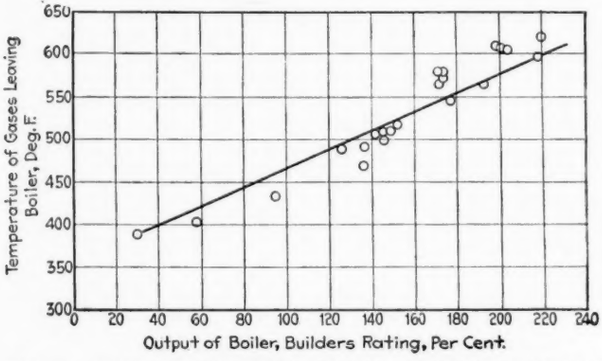


FIG. 1. FLUE TEMPERATURES FOR VARIOUS RATINGS

The combined boiler and furnace efficiency of any standard water-tube boiler properly maintained depends chiefly on the furnace conditions or upon the stoker design and operation. The principal operating loss is the heat carried away by the flue gas—small at light loads, but large at heavy loads. This loss is proportional to the product of the weight of the gas times the difference in the flue-gas and air temperatures. Practically, the flue-gas temperature increases directly with the boiler load, and the weight of flue gas under good operation with nearly constant CO_2 varies almost directly with the output; that is, approximately,

$$Weight\ of\ flue\ gas = k \times output,$$

where k is a constant used to denote the ratio of pound of flue gas per boiler horsepower-hour.

$$Temperature\ of\ flue\ gas = k_2 + k_3 \times output$$

where k_2 equals the difference between the temperatures of the boiler water and the air and k_3 denotes the rate of rise in flue temperature with load.

The flue-gas loss in B.t.u. then equals

$$(k_1 \times output) \times (k_2 + k_3 \times output)$$

Simplifying,

$$Flue\text{-}gas\ loss = A \times output + B \times output^2.$$

This loss may be expressed in B.t.u., boiler horsepower hours or in percentage of builders' rating, by giving A and B the proper values.

*Engineer, West Virginia Pulp and Paper Co., Fifth Avenue Building, New York City.

Fig. 1 shows the relationship, in a typical case between the output and the flue temperature. Fig. 2 shows the loss C denoted by $B \times \text{output}^2$; small at light loads, but large at heavy loads.

There are miscellaneous losses, such as radiation, refuse loss and steam formed by burning hydrogen to steam, which are proportional to the first power of the output; that is, miscellaneous losses $= A_1 + B_1 \times$ output, where A_1 and B_1 are constants depending on the design and operation of the apparatus and the unit in which the loss is expressed. This loss A_1 is a fixed loss, which would occur at all loads and would be the input to the boiler necessary to maintain steam pressure without carrying any load. It can therefore be termed as the constant or "no-load" loss.

Consequently the input to the boiler is approximately $A_1 + (A + B_1) \times$ output $+ B \times$ output^2 + output. The efficiency then equals

$$\frac{1}{\frac{A_1}{output} + (A + B_1) + B \times output + 1}.$$

For maximum efficiency,

$$Output = \sqrt{\frac{A_1}{B}}$$

In curve A, Fig. 2, this value, $\sqrt{\frac{A_1}{B}}$, equals 70 per cent. The relatively larger the no-load loss, the greater will be the output for maximum efficiency.

Curve B, Fig. 2, is plotted from tests running from 30 to 238 per cent. of builders' rating. The values of input are expressed in percentage of builder's rating for convenience and are found by dividing the various outputs, expressed in per cent. of rating, by the corresponding efficiencies found from tests. For example, a 100-hp. boiler operating at 100 per cent. builders' rating, requires the conversion of 3,347,900 B.t.u. per hr. from the coal to the steam. Assuming that 340 lb. of coal of 14,500 B.t.u. heating value are required per hour,

$$Efficiency = \frac{3{,}347{,}900}{340 \times 14{,}500} \times 100 = 67.8\ per\ cent.$$

$$Input = \frac{100}{0.678} = 147.4\ per\ cent.$$

The same result may be obtained by

$$\frac{340 \times 14{,}500}{3{,}347{,}900} \times 100 = 147.4\ per\ cent.$$

To illustrate the no-load loss principle, curve B is extrapolated to zero output, following the same law as between 30 and 238 per cent. The no-load input, or loss, is found to be approximately 9 per cent. of the rated output.

There is no reason for assuming that the direction of curve B below 30 per cent. will vary materially from that

shown. The lower values of A are then calculated from curve B, which shows a maximum efficiency at about 70 per cent. of rating.

It is quite possible, however, in certain installations, where the boiler-heating surface is small and the setting is large comparatively, or the boiler iron is exposed to radiation, or the grate is extremely large for the boiler,

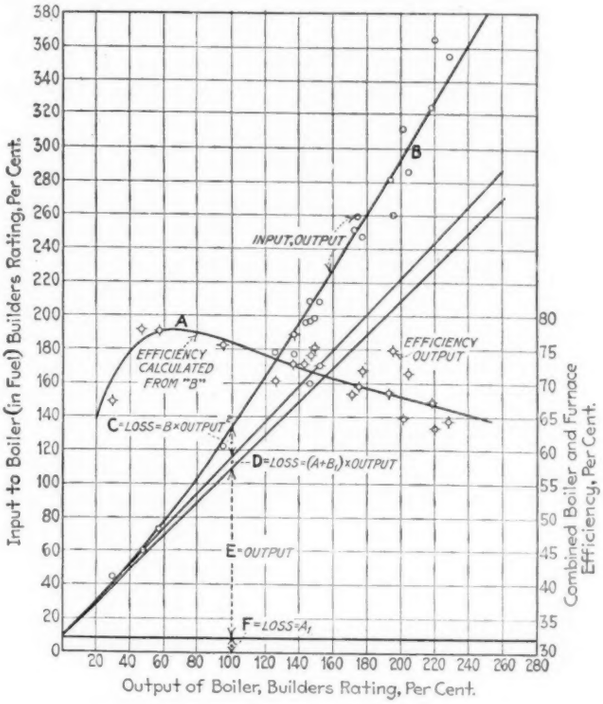

Input to Boiler (in Fuel) Builders Rating, Per Cent.
Combined Boiler and Furnace Efficiency, Per Cent.
Output of Boiler, Builders Rating, Per Cent.
INPUT, OUTPUT
EFFICIENCY CALCULATED FROM "B"
EFFICIENCY = OUTPUT
C = LOSS = B × OUTPUT
D = LOSS = (A + B1) × OUTPUT
E = OUTPUT
F = LOSS = A1

FIG. 2. RESULTS OF MANY TESTS SHOW THAT HIGHEST EFFICIENCY OCCURS BELOW BUILDER'S RATING

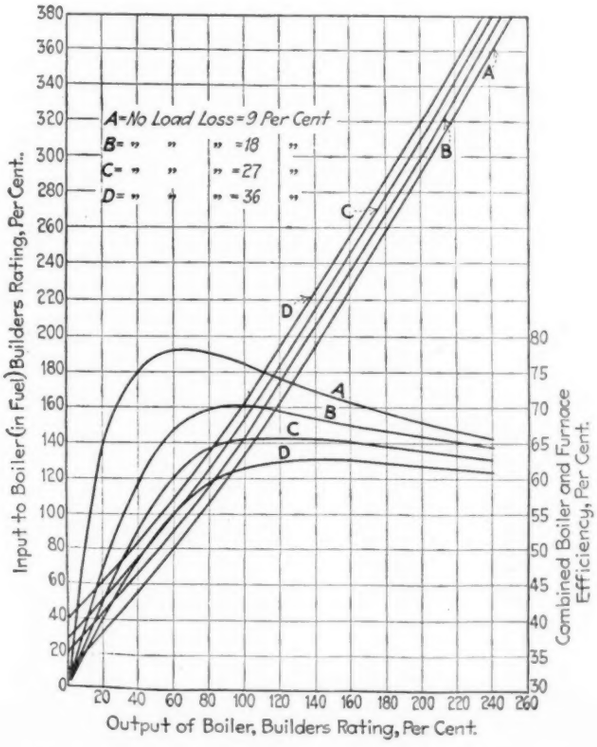

Input to Boiler (in Fuel) Builders Rating, Per Cent.
Combined Boiler and Furnace Efficiency, Per Cent.
Output of Boiler, Builders Rating, Per Cent.
A = No Load Loss = 9 Per Cent
B = " " = 18 "
C = " " = 27 "
D = " " = 36 "

FIG. 3. SHOWING INFLUENCE OF NO-LOAD LOSSES ON EFFICIENCY

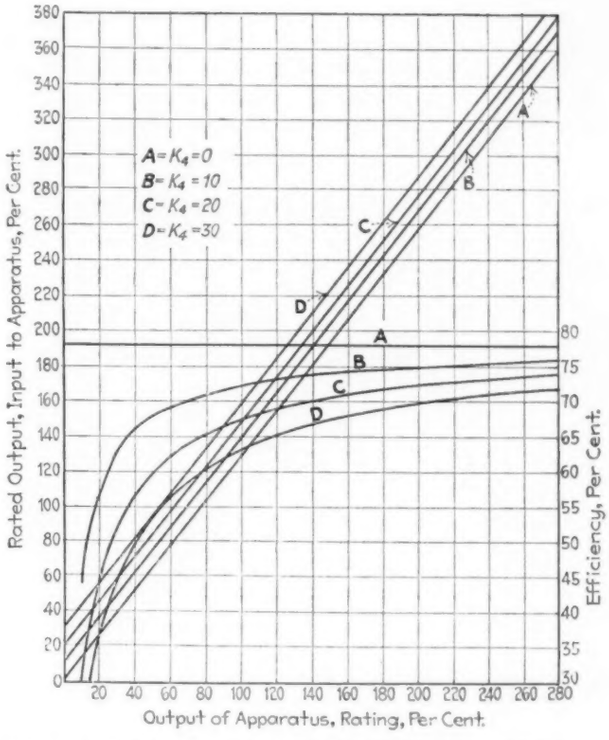

Rated Output, Input to Apparatus, Per Cent.
Efficiency, Per Cent.
Output of Apparatus, Rating, Per Cent.
A = K4 = 0
B = K4 = 10
C = K4 = 20
D = K4 = 30

FIG. 4. PERFORMANCE WITH NO LOSSES PROPORTIONAL TO THE SQUARE OF THE OUTPUT

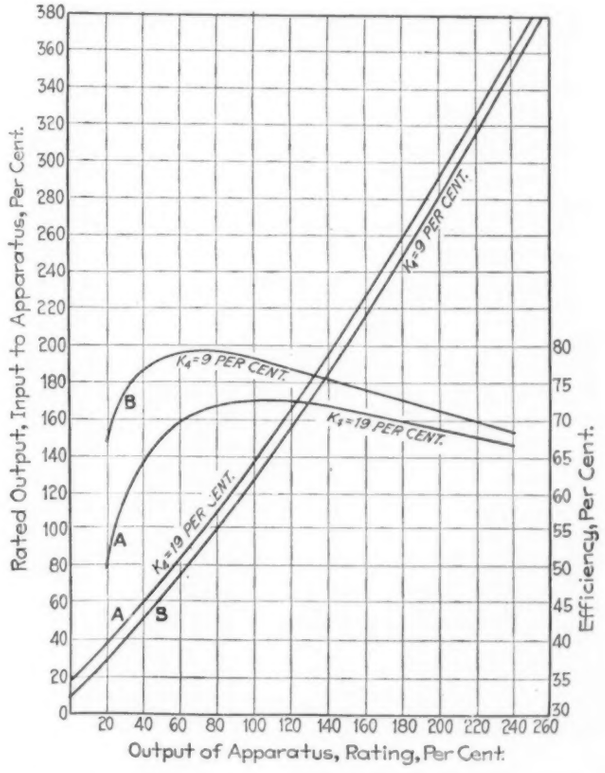

Rated Output, Input to Apparatus, Per Cent.
Efficiency, Per Cent.
Output of Apparatus, Rating, Per Cent.
K4 = 9 PER CENT.
K4 = 19 PER CENT.

FIG. 5. HOW THE NO-LOAD LOSSES EFFECT THE EFFICIENCY

for the no-load losses to form a larger percentage than that indicated. On the assumption that the input to a boiler is approximately $A_1 + (A + B_1) + \text{output} + B \times \text{output}^2 + \text{output}$, Fig. 3 is plotted with the same load losses in all cases, but with no-load losses of 9, 19, 29

and 39 per cent. respectively. By "load-losses" are meant losses which increase with load, such as flue-gas loss, refuse loss and radiation loss, which are expressed by $(A + B_1) \times \text{output} + B \times \text{output}^2$. Here the influence of the no-load loss on the point of maximum efficiency is illustrated. That is, with installations of high no-load losses, the output for maximum efficiency is greater than with installations of low no-load losses. In practice, however, the maximum operating efficiency is found at or slightly under builders' rating and an overloaded boiler is working disadvantageously as regards steam-production costs.

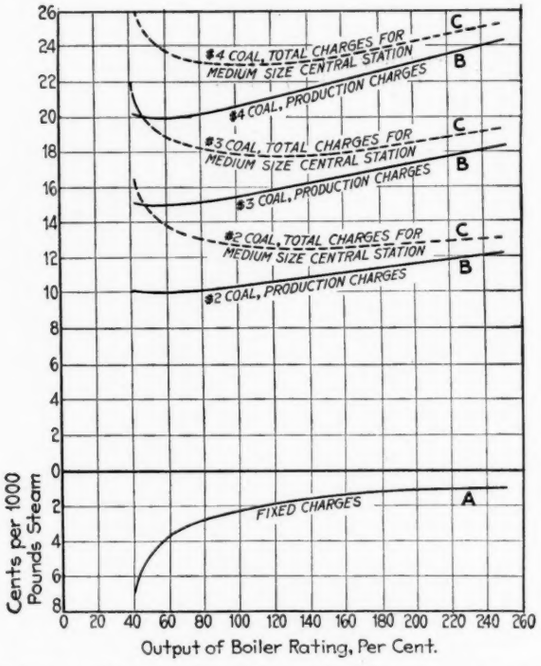

$4 COAL, TOTAL CHARGES FOR MEDIUM SIZE CENTRAL STATION
$4 COAL, PRODUCTION CHARGES
$3 COAL, TOTAL CHARGES FOR MEDIUM SIZE CENTRAL STATION
$3 COAL, PRODUCTION CHARGES
$2 COAL, TOTAL CHARGES FOR MEDIUM SIZE CENTRAL STATION
$2 COAL, PRODUCTION CHARGES
FIXED CHARGES
A
B
C
Cents per 1000 Pounds Steam
Output of Boiler Rating, Per Cent.

FIG. 6. SHOWING EFFECT OF FIXED CHARGES ON PRODUCTION COSTS

Fig. 4 illustrates the performance of an apparatus where there are no losses proportional to the square of the output; that is, input $= K_4 + K_5 \times \text{output} + \text{output}$: K_4 is the no-load loss and K_5 is a constant for the particular apparatus. Where $K_4 = 0$, the efficiency is constant at all loads. Where there are no-load losses, the efficiency increases with the load indefinitely. Consequently, the higher the load, the lower the production costs.

Fig. 5 illustrates the performance of an apparatus where input $= K_4 + K_6 \times \text{output}^2 + \text{output}$, where K_6 is a constant for the particular apparatus. These, as in the boiler-performance curve, show the influence of the no-load and output^2 losses upon the point of maximum efficiency.

It is evident that a boiler and furnace operation fulfills the condition where forcing beyond a certain point will cause a falling off in efficiency. The losses on account of the power required for stoker and fan drive will slightly change the point of maximum efficiency. Also, the difficulty of stoker and fan control at ratings below 80 or 90 per cent. makes operation below these points undesirable.

However, decreased production cost is not the reason for overloading boilers. Fig. 6 shows the effect of fixed charges, such as interest on investment of boiler-room apparatus, upon the total cost of steam, with different production costs, as influenced by the price of high-class soft coal. The heating value of coal in all cases is assumed to be the same, the variation in price being due to difference in freight, cost of handling, etc. The higher the overload, the less the fixed charges; the lower the cost of coal, the higher the load for lowest total cost.

With a steady demand for steam under average circumstances it will pay to design a boiler plant to operate continuously at from 100 to 150 per cent. of rating. But a reduction of steam demand in a steady-load plant already built does not call for a reduction in the number of active boilers until their output falls below rating.

In a plant to be designed for a variable load, the maximum overload to be carried at the lowest total cost depends upon the form of the load curve. Peaks of short duration should generally be carried by forcing the boilers, allowing them to operate at near rating the rest of the time, while the resulting high production costs during peaks may be more than counterbalanced by the money saved in eliminating banked fire losses and the fixed charges on reserved boilers used only for peaks.

In some older plants, where improvements in prime movers make economically possible large increases of power in existing engine rooms, it may happen that overloading the existing boilers, even at a loss of operating efficiency, may pay. Here, the saving of investment charges of new boilers, superheaters, stokers, building, etc., is greater than the increase in production costs.

Much has been said concerning overloading boilers and the increased efficiency resulting therefrom; but the evidence of hundreds of carefully conducted tests, analyzed by the method shown in Fig. 2, indicates that the maximum efficiency of operation occurs at or slightly under builders' rating.

Convenient Water Brake

By Thomas Hall

While the water brake is not new, its use is by no means common, and if this simple device were better known, no doubt it would find many applications.

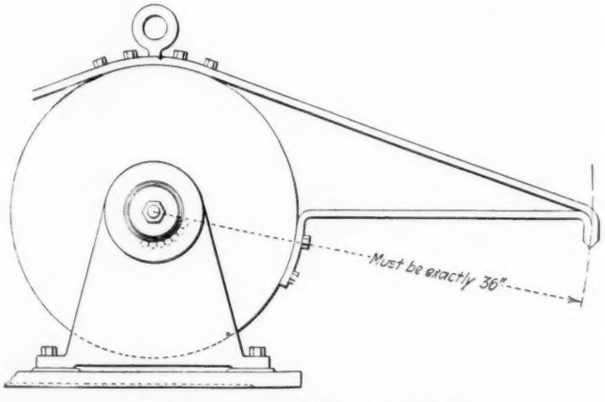


FIG. 1. EXTERIOR OF BRAKE

The drawings show this type of prony water brake adapted to small-motor testing. The revolving blades, twelve in number, are $\frac{1}{8}$ in. thick, of hardened and ground saw-blade material. The eleven stationary plates are of the same thickness and material, and the space on each side between the stationary and revolving plates is $\frac{1}{16}$

in. The bearings are bronze-lined, and surrounding each is a roller bearing which serves to hold the casing in the pedestals and permits free rocking, or cradle action. The arm attached to the case is 36 in. long from the center of the shaft to the knife-edge.

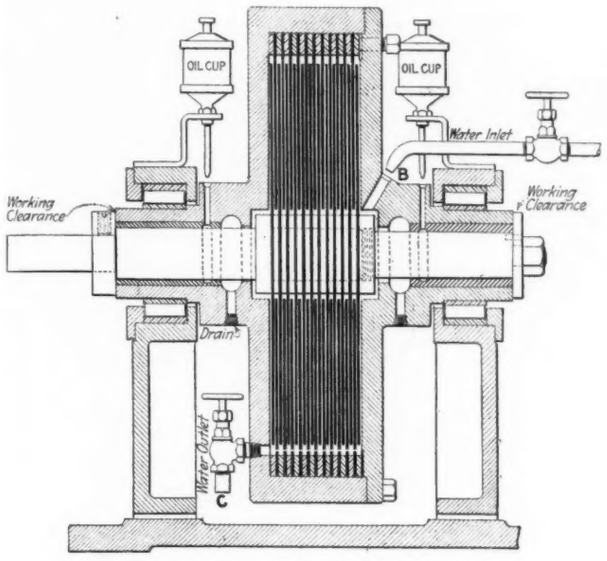


FIG. 2. SECTION THROUGH BRAKE

The motor to be tested is connected to the shaft by a coupling, and when started, load is applied by admitting water at *B;* the outlet is at *C*. The centrifugal force of the revolving disks maintains a ring of water in the case at the outer periphery, the depth of this ring of water being varied by adjusting the valves and thus controlling the load required. This adjustment has proven very sensitive and satisfactory, much more so than any other type of brake.

This brake, when running at 1,200 r.p.m. with all twelve disks in place, can easily be adjusted to measure as low a load as ½ hp., and by taking out some of the disks it will work satisfactorily at less power. On the other hand, it has been used with excellent results at 1,200 r.p.m. when absorbing 25 hp.

The capacity of this type of brake may be determined by the formula,

$$W = \frac{0.145\, D N^2 (R_1^4 - R_2^4)}{L}$$

Where

W = Weight in pounds on scales;
L = Length of brake beam in feet, which in this case is 3 ft.;
D = Number of revolving disks;
N = Revolutions per minute;
R_1 = Radius of disk in feet;
R_2 = Radius of hub in feet, or, if figuring the power for any condition less than full capacity it is the inner radius of the ring of water.

Having determined W, the horsepower is figured from

$$Horsepower = \frac{\pi W L N}{33{,}000}$$

[After the brake has been built and is in actual service, W is determined by the scales.—Editor.]

Cost of Coal and Oil as Fuel

By Perry Barker*

SYNOPSIS—The factors that influence the relative merits of coal and oil as fuel.

The abnormal conditions of transportation brought about by the European War have affected the price of coal, particularly in New England, and many consumers are investigating the possibilities of oil as a boiler fuel. The interest in this fuel has also been materially increased by the attractive prices at which certain grades of oil residues have been offered to prospective customers, particularly those in New England.

When investigating the relative value of coal and oil as boiler fuels, a number of items must be considered. The fuel consumer must first have available data to determine the costs for producing a unit quantity of steam in his plant both with coal and with oil. The cost of steam includes fuel, labor, fixed charges and supplies. In addition to these items, which actually determine the cost of steam generation, certain factors whose effect cannot be definitely expressed in money value may have considerable importance in the selection of the fuel to be used. Among these may be mentioned the smoke nuisance in violation of civic ordinances or affecting manufactured product, noise and cleanliness in the boiler room, increase in boiler output, the fuel-storage problem and the question of a continuous supply of fuel at a price that will be nearly the same as when the comparison was made.

The first factor in this comparison is the respective heating value of the two fuels. On account of the variations in heating value of both coal and oil, no definite calorific standards can be stated. In general, fuel oil will contain about 30 per cent. more heat units per pound than coal. As the prices for fuel oil are quoted on the basis of a barrel of 42 gal., it is necessary to know the heating value per gallon or barrel. This figure may be determined from the calorific value per pound and the gravity, the latter indicating the number of pounds per gallon.

In comparing the fuel costs of coal and oil, the heating value per unit of price is not the only determining factor. The percentage of this heat that can be usefully employed in the generation of steam or the boiler and furnace efficiency is of equal or greater importance The heat so utilized will vary from 45 to 85 per cent. of the calorific value of the fuel, or the losses will total from 15 to 55 per cent.

An excellent graphic representation of the relative costs of fuel for generating steam with coal and oil was presented in *Power* of Dec 14, 1915. An extension of these calculations based on comparatively small variations in the gravity of fuel oil is shown in the accompanying chart, the use of which may be understood from the dotted lines, assuming the following values:

*Fuel engineer, Boston, Mass.

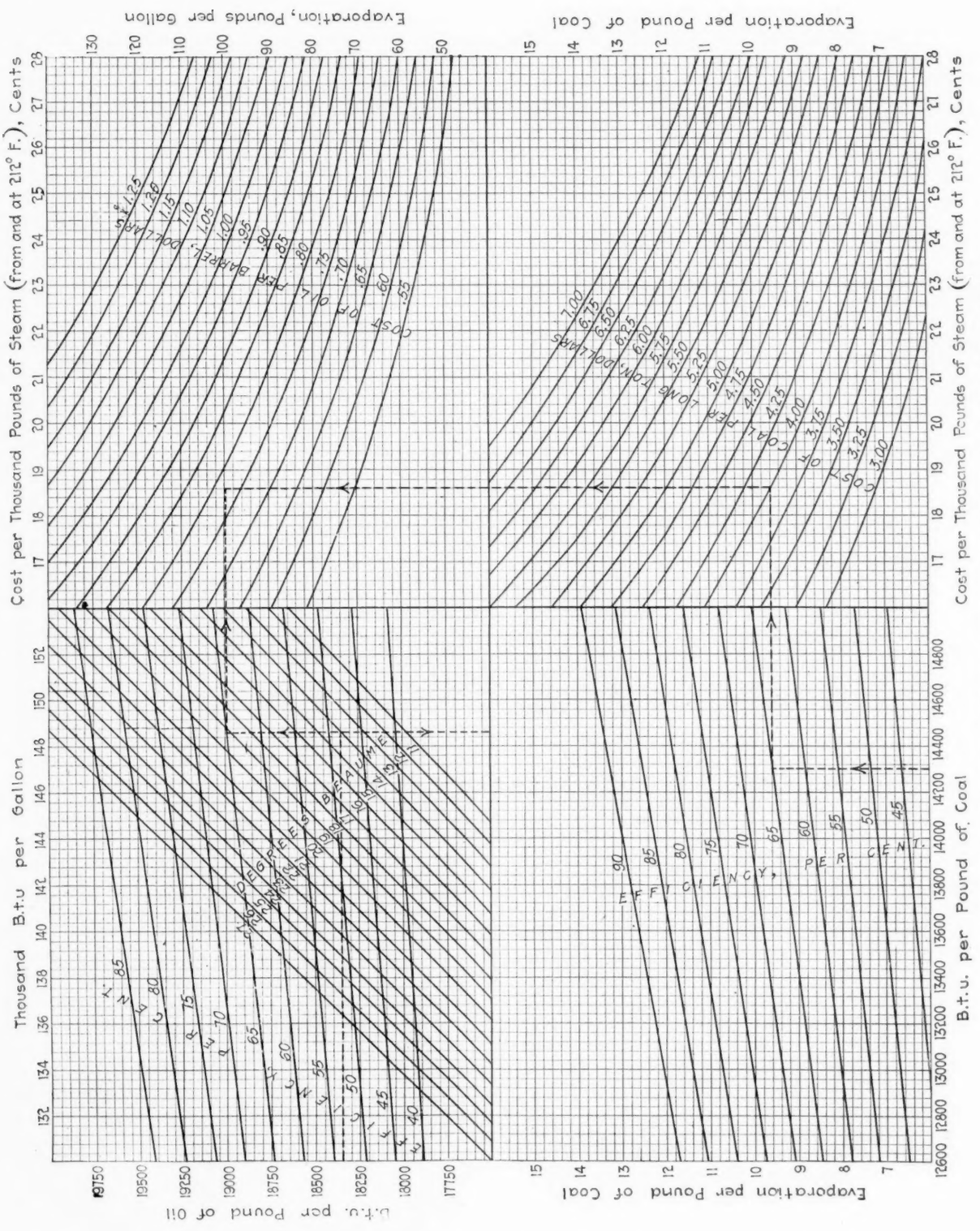

Evaporation, Pounds per Gallon
Evaporation per Pound of Coal
Cost per Thousand Pounds of Steam (from and at 212° F.), Cents
Thousand B.t.u. per Gallon
B.t.u. per Pound of Oil
B.t.u. per Pound of Coal
EFFICIENCY, PER CENT.

CHART FOR DETERMINING THE COMPARATIVE COST OF COAL AND OIL AS FUEL

Coal at $4 per long ton, having a heating value of 14,300 B.t.u. per pound as fired and burned with a boiler and furnace efficiency of 65 per cent.; to determine the maximum price per barrel that should be paid for fuel oil with a gravity of 14 deg. Bé. (8.10 lb. per gal.), having a heating value of 18,350 B.t.u. per pound and burned with an efficiency of 65 per cent.

The B.t.u. per pound of coal is located in the lower left-hand section of the chart. This point is projected upward to the intersection with the 65-per cent. efficiency line. From this point, in a horizontal line through the evaporation of 9.6 lb. of water from and at 212 deg. F. per pound of coal, the intersection with the curve for coal at $4 per long ton is located. Passing vertically upward from this point, the cost per 1,000 lb. of steam is found at 18.6c.

The B.t.u. per pound of oil is in the upper left-hand section of the chart. This is followed horizontally to the intersection with the 14-deg. Bé. line. Passing downward, or upward, the B.t.u. per gallon is 148,600. Project-

ing this point upward to the intersection with the 65-per cent. efficiency line and horizontally through the evaporation per gallon, 99.8 lb., it is found that the intersection with the price of steam as determined for coal, 18.6c. per 1,000 lb., comes at 78c. per bbl. of oil, which will represent the equivalent value of this fuel.

In most steam plants the amount of labor required will be less with fuel oil than with coal. The saving in labor when oil is used in a plant that formerly burned coal will depend upon the method of handling coal into storage and from storage to the boiler room, the boiler-load conditions, the type of equipment and the efficiency of the men in the fireroom. It is reported that a saving of 80 per cent. in labor was effected in the largest oil-burning plant in New England when this fuel was substituted.

In a hand-fired mill boiler plant of average size, with coal at $4 per long ton, the cost of steam will be about $0.25 per 1,000 lb. This charge is based on an average boiler efficiency of 65 per cent., allowing 12 per cent. of the coal fired during day operation for banking and heating at night. The distribution of the total cost will be about as follows, per 1,000 lb. of steam: Fuel, $0.20; labor, $0.03; fixed charges, $0.02; total, $0.25.

The reduction in labor in hand-fired plants of less than 2,000-boiler-horsepower capacity will not be much greater than 50 per cent., or $0.015 per 1,000 lb. of steam. It will be noticed that this figure is 6 per cent. of the total or 7.5 per cent. of the fuel cost. Therefore, with fuel oil at $1 per bbl., an increase in price of 7.5c. will entirely offset the labor saving.

The investment for equipping a coal-fired plant to burn fuel oil depends upon the size and layout of the apparatus in the boiler room. The location of the plant with respect to the source of fuel-oil supply will have a material effect upon the cost of the installation, since storage tanks constitute a large percentage of the investment. It is estimated that complete equipment will cost $5 to $10 per boiler horsepower. If the cost of this equipment is taken care of in the fixed charges during the life of the fuel-oil contract, which is usually five years, it will represent an addition of 0.7 to 1.4c. to the charge per 1,000 lb. of steam or 3 to 6 per cent. of the cost of steam generation.

In considering the relative merits of coal and oil, each boiler plant should carefully determine the efficiency and labor cost while burning coal with the existing equipment and operating conditions. If a change to oil seems advantageous, similar data should be obtained with that fuel before any definite statement can be made regarding the saving to be effected. The figures and conclusions may be based upon fuel costs, labor saving, increased boiler capacity and convenience, but the future prices of oil will in most cases determine the advisability of its use.

Troubles and Care of Ammonia Compressor Valves--II

By A. G. Solomon

SYNOPSIS—Tells of the construction and the troubles to look for in the valves of two well-known compressors.

The horizontal double-acting "Triumph" ammonia compressor has distinctive features in valve construction and operation. We will consider these features of the machine.

The valves, Figs. 5 and 6, are contained in cages that fit into port openings in the cylinder heads. There is a ground joint between the cage and the head. Instead of the valve bonnet holding the cage to its seat as in some compressors, there is a ring screwed into the head casting. This ring has two setscrews through it, which force the cage firmly to its seat. Leakage between the head and cage is rare, and the cage can never come loose.

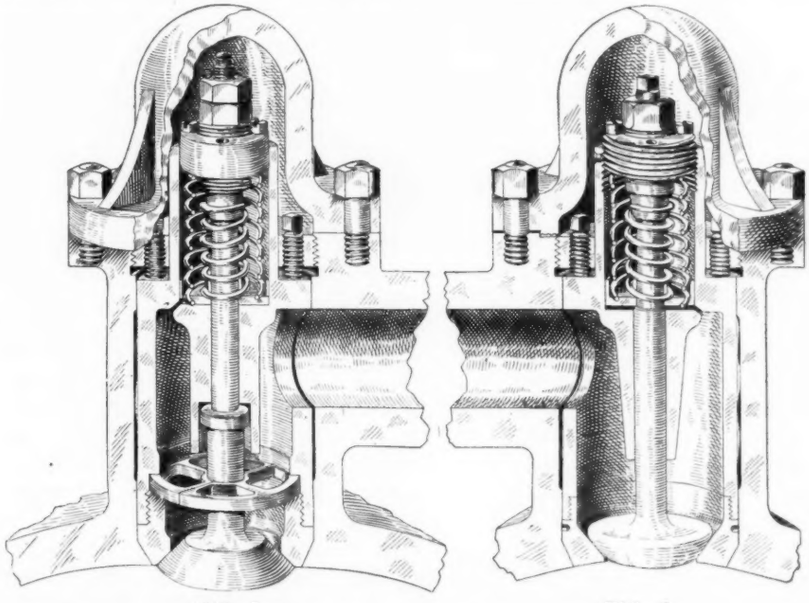


FIG. 5 FIG. 6
THE VALVES OF THE TRIUMPH COMPRESSOR

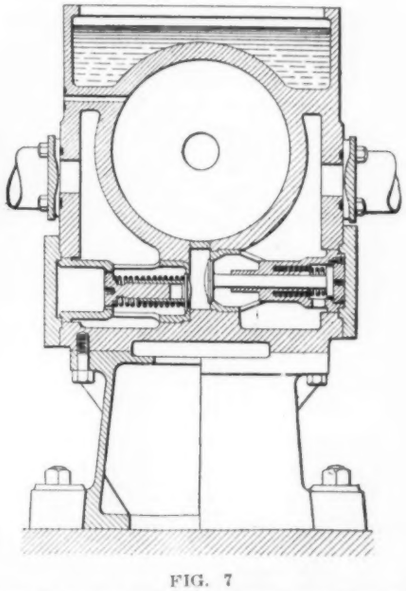


FIG. 7
END SECTION DE LA VERGNE MACHINE

The most important feature of the valves is that provision is made for adjusting the valve-spring tension. Too great tension on the suction-valve spring will cause restricted passage and prevent the cylinder from filling with vapor at the pressure in the suction line. The higher

FIG. 8. DE LA VERGNE SUCTION VALVE ASSEMBLED AND DISASSEMBLED

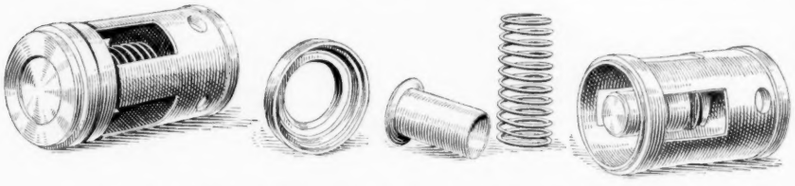


FIG. 9. DE LA VERGNE DISCHARGE VALVE ASSEMBLED AND DISASSEMBLED

the back pressure the greater the tension necessary on the suction-valve spring and vice versa.

The screwed collar that holds the valve cage prevents ammonia collecting in the valve bonnet. It also provides for easily removing the bonnet and for adjusting spring tension while the machine is operating. There is liability of ammonia leaking by the ring or valve stem, so when the bonnet is to be removed, it is advisable to slack off just a little on the nuts and allow the gas to escape.

The tension of both the working and cushion spring is adjusted separately by the collars—the inside collar for the cushion spring and the outside one for the working spring. One turn of these collars is usually sufficient for a variation of about 5 lb. pressure. After adjusting the tension, the collars are secured by the screws, which act as keepers. After a little practice these valves can be made noiseless when operating under almost any pressure conditions.

Danger of the suction valve dropping into the cylinder is reduced by the safety collar, which fits in the cage and through which the valve stem passes. Above this safety collar is a collar turned on the valve stem. The stem can break above this collar with no serious results.

The discharge valve is fitted with the same arrangement for spring adjustment as the suction valve.

The departure from the nonclearance machines is plainly seen in the construction of the De La Vergne compressor. On other machines the makers have done everything possible to reduce the clearance space.

As seen in Fig. 7, the suction and discharge valves are below the cylinder and there is a space between them. With this construction there is no possibility of a broken valve getting into the cylinder. The space between the suction and discharge valves is just sufficient for the suction valve to open to its full extent. Both valves have gas cushion instead of buffer springs, so spring trouble is minimized. Details of the valve construction are shown in Figs. 8 and 9.

[The next article on this subject by Mr. Solomon completes the series.—Editor.]

Required Bearing Area is the total pressure divided by the allowable pressure per square inch, giving the required projected area in square inches.

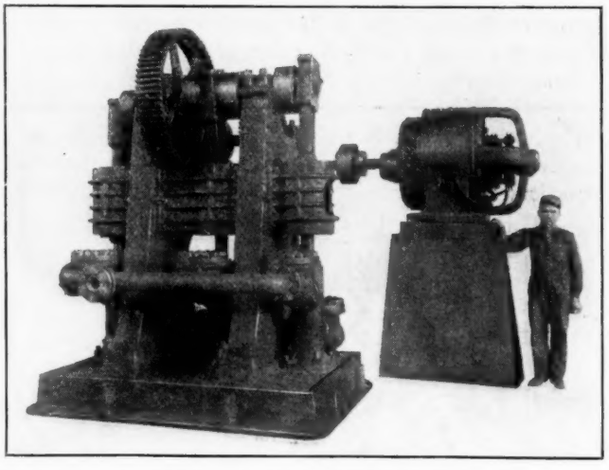
"Wooster" Solid-Woven Belting

Solid-woven belting, known as the "Wooster" brand, is the principal product of the Duryea Manufacturing Co., 69 Wall St., New York City. The solid-woven body eliminates laps, plies, stitches and cemented parts. The claim is made that there is no "interply friction," as the woven fibers rotate over one another on a central axis, and sectional resistance is also declared to be done away with.

This belting is impregnated with asphaltum to enable it to resist moisture, steam, acid fumes, alkali and gases, and as a conveyor to handle hot material at temperatures up to 300 deg. F. The aim in the finished product is to get a belt that is oilproof and waterproof, and of greater tensile strength than the raw cotton fiber by a tested factor of about 15 per cent. The common weakness of all forms of frictional power transmission is their natural tendency to slip, which prevents running them slack. The asphaltum impregnation of Wooster belting causes an average increase in the frictional coefficient, as well as a particular increase in the coefficient of friction under wet and oily conditions.

Triplex Hydraulic Pump

The illustration shows a new vertical triplex hydraulic pump designed and built by the Hydraulic Press Manufacturing Co., Mount Gilead, Ohio. It is of the pot-



TRIPLEX HYDRAULIC PUMP

valve type and is capable of delivering a large volume of water against high pressure. The volume of water and the pressure depend upon the diameter of the plungers with which the pump may be equipped. These may vary from 4 to 5¾ in. The capacity of the pump varies proportionately with the intervening sizes of plungers.

Each plunger has a stroke of 12 in., with a normal speed of 45 strokes per minute.

This pump is designed for direct-connected motor drive only and requires a 100-hp. motor for operating. The height of the pump is 10 ft., while the floor space required, without the motor, is 8 ft. by 5 ft. 9 in.

Handling Coal and Ashes at Northwest Station

By Thomas Wilson

SYNOPSIS—An unusually complete system, including electric locomotives for switching facilities, designed to care for 3,000 tons of coal per day. In the yards there is storage space for 300,000 tons, which will carry the plant over a period of three months.

As previously stated in these columns, the Northwest Station of the Commonwealth Edison Co. of Chicago is to have an ultimate capacity of 180,000 kw. in six units. Over 40 per cent. of this capacity has been installed, a fourth unit is now being built and the two remaining ones, which will complete the equipment of the station, will be installed in the not distant future.

To supply fuel for a peak load of 180,000 kw. is a task of some magnitude. The requirements are approximately 3,000 tons of Illinois coal per day of 24 hr. This amount of coal would occupy a volume of 120,000 cu.ft., which would be contained in a pile 100 ft. square and 12 ft. high. To carry it would require 75 railway cars, which must pass into and out of the plant every day, and in addition about 10 cars of ashes would have to be removed.

As much of the coal comes from the central part of the state, some storage is necessary to tide over unavoidable delays. Only a four days' supply in cars would require about 2½ miles of track for 300 cars, and in the event of interference with the coal supply, large storage space in the yards would be necessary to bridge the interval during which no coal is coming in. Such was the problem to be worked out for the Northwest Station, and as will be shown later, the system for handling daily this great volume of coal is unusually complete and convenient. From the coal in the railway car to the ashes no manual labor is required. Conveyors do part of the work and gravity completes it.

The plant is served by a system of tracks connecting the main coal storage and the power plant with the Chicago & Northwestern Ry. about a mile distant from the station. Two 60-ton electric locomotives of the same type employed by the New York Central R.R. for suburban service are used to switch the coal and ash cars about the property. In the yards there is space to store 300,000 tons in two long piles, one or both of which may eventually be served by gantry cranes having a span of 250 ft. If this total amount of coal storage were utilized, it would carry the plant for three months. See Fig. 1.

Twelve tracks will lead into the boiler room, one for coal and one for ashes for each row of boilers, or in other words, for each unit. The cars enter the boiler-room basement 28 ft. below the boiler room floor, as indicated in Fig. 2, a sectional view of part of the plant. It will be seen in the drawing that the general scheme is to have two rows of boilers face each other on a central aisle 40 ft. wide and 200 ft. long. Over this space is the coal bunker for the two units in question. It will hold when level, full, 1,800 tons of coal. Below in the basement are the track hoppers. Still lower, in a pit, is a traveling crusher, and at a depth of 60 ft. below the boiler-room floor in the same pit are the lower runs of the bucket conveyors serving the two rows of boilers. For each unit there is also an ash track immediately under the ash hoppers, which are large enough for a day's run. From a fine-coal hopper under each stoker the siftings from the grate are chuted back to the large track hopper serving the two units in common.

Over the two coal tracks eight cars can be unloaded at one time, or about 320 tons. The hopper itself, which in reality is a series of ten V-shaped hoppers each 18 ft. long, has a capacity of 850 tons. A traveling crane having a 2-yd. bucket and a capacity of 175 tons per hour is provided to unload gondola cars, those of the bottom-dump type being discharged directly into the hopper.

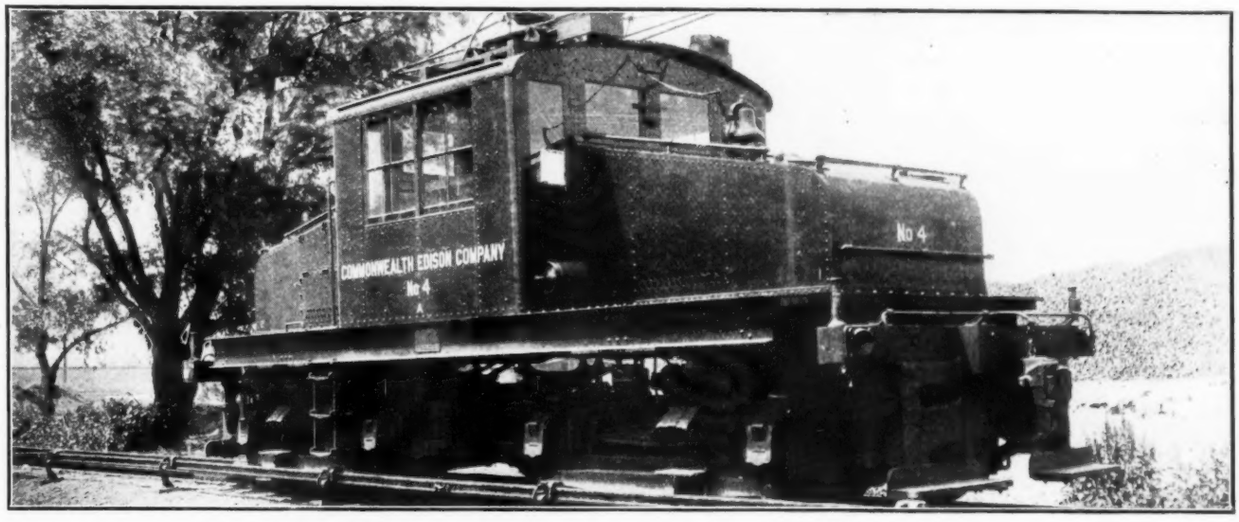


FIG. 1. ONE OF THE ELECTRIC LOCOMOTIVES FOR HAULING COAL AND ASHES

From the track hopper the coal passes through a reciprocating feeder directly to the conveyors or into a 28x48-in. Link-Belt four-roll electrically operated traveling crusher. Its capacity is 200 tons per hour when crushing run-of-mine or lump coal up to 24-in. cubes to a degree of fineness necessary for 90 per cent. of it to pass through a ¾-in. ring and all through a 1-in. ring. The crusher is one of the largest of its type in service. It has toothed solid cast-steel upper rolls designed to operate at 75 r.p.m., while the two lower rolls make 150 r.p.m. That one or all of these rolls may be removed without dismantling the frame is a feature of this equipment.

Primarily the driving mechanism consists of a 60-hp. slow-speed induction motor complete with a reversing-drum controller, oil-break switch and rheostat. It receives three-phase 60-cycle 220-volt current through sliding contacts on flat copper bars mounted along the wall. As is shown in Fig. 4, the motor is mounted on the traveling frame. A silent chain drive connects it to a jackshaft which has driving connections to the crusher, the feeder and to one of the two pairs of truck wheels supporting the frame. Chain drives equipped with friction clutches are used for traversing the crusher at an approximate speed of 100 ft. per min. and operating the feeder, while a belt having a counterweighted tightener turns the crusher rolls. From the operator's platform the motor can be stopped by a push-button and the travel mechanism brought to a stop under a receiving hopper with a band brake operated by a foot pedal. In

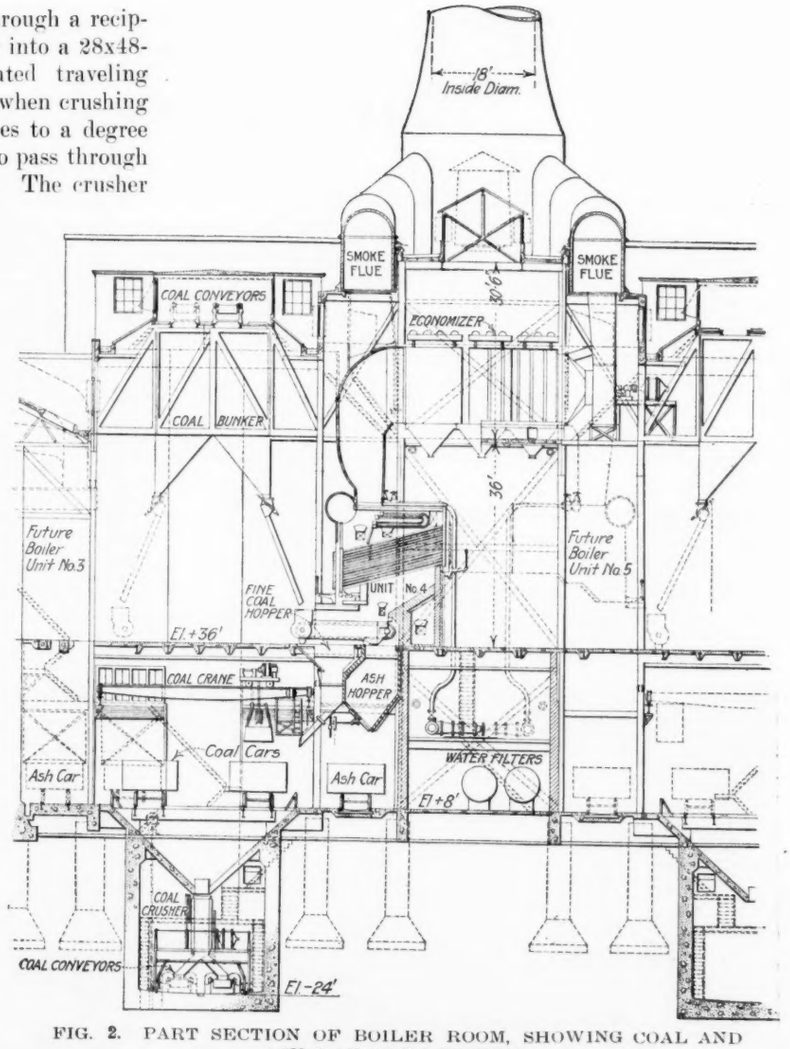


FIG. 2. PART SECTION OF BOILER ROOM, SHOWING COAL AND ASH-HANDLING SYSTEM

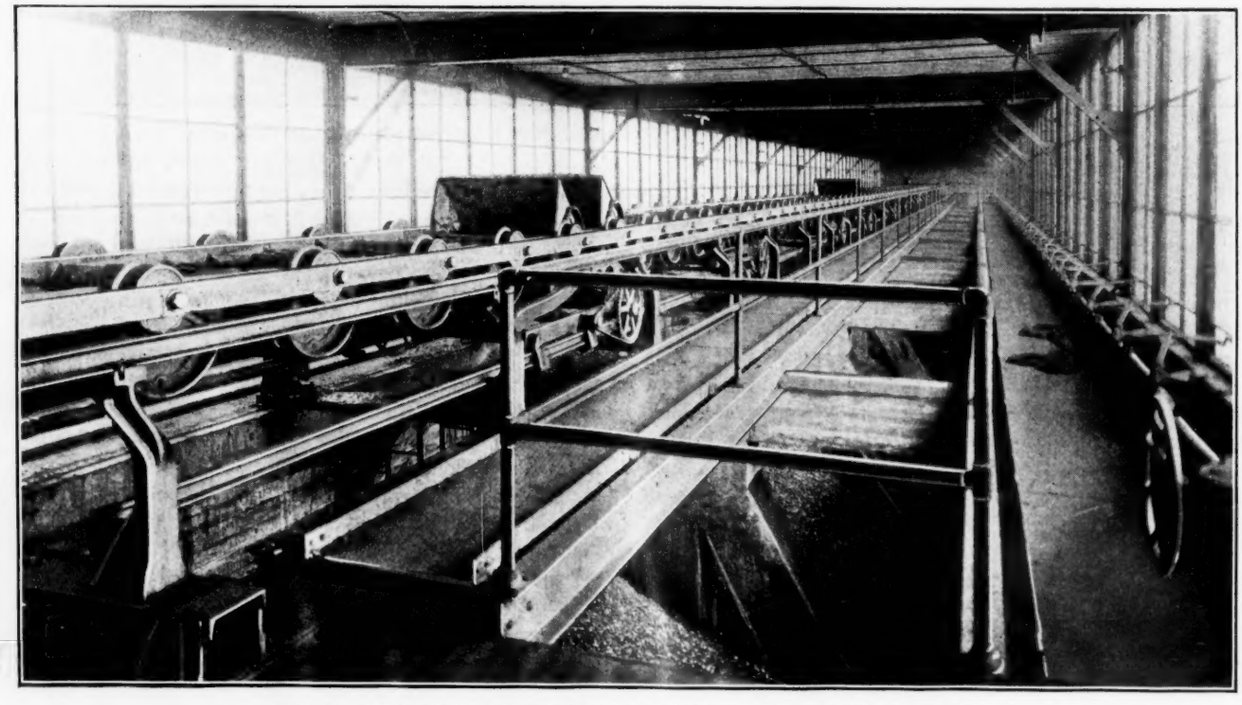


FIG. 3. CONVEYOR RUN OVER THE TOP OF THE COAL BUNKER

the drawing it will be seen that the crusher frame straddles two continuous conveyors, one for each row of boilers. A two-way discharge chute under the crusher has a butterfly valve so arranged as to deflect all or half of the coal into either conveyor. Each of the latter consists of 625 lin.ft. of Peck carrier line made up of overlapping malleable-iron buckets, 30 in. pitch and 36 in. wide, attached to and supported by two strands of forged steel chain. Conveyor wheels 8 in. diameter travel on 30-lb. T-rails and guides. The driving corner consists of an 8-in. headshaft, two geared countershafts, two sprockets of 30 in. pitch, a pair of spur equalizing gears to obviate the pulsating motion incident to the use of long-pitch chain, a pair of cut-steel spur gears between the countershafts, a safety pawl to prevent backward movement of a loaded carrier should current be cut off from the motor, and a silent chain drive from the motor. The latter is of the induction type rated at 50 hp.

Floor stands spaced 7 ft. apart support the horizontal runs of the conveyor; above the bunker ten stationary dump blocks have been provided on each carrier. Each has a handwheel-operated mechanism to throw it in or

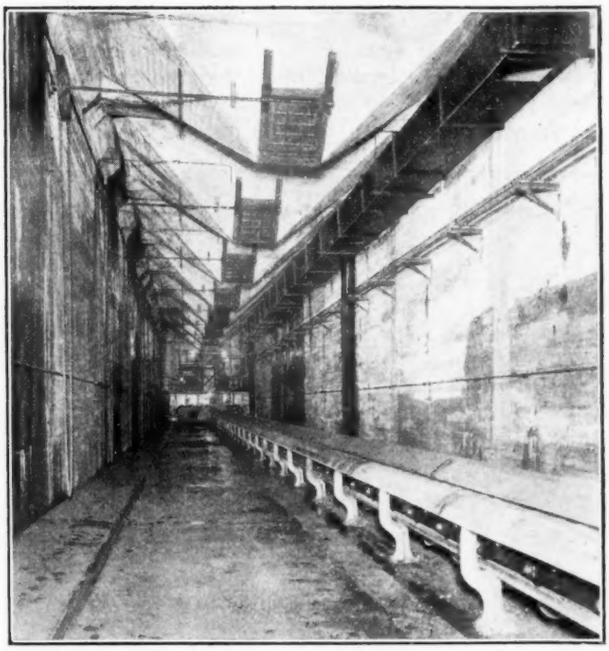


FIG. 4. FOUR-ROLL ELECTRIC TRAVELING CRUSHER IN BACKGROUND; ONE CONVEYOR INSTALLED

out of line with the dumping cams which are riveted to the buckets. Fig. 3 shows this part of the conveyor.

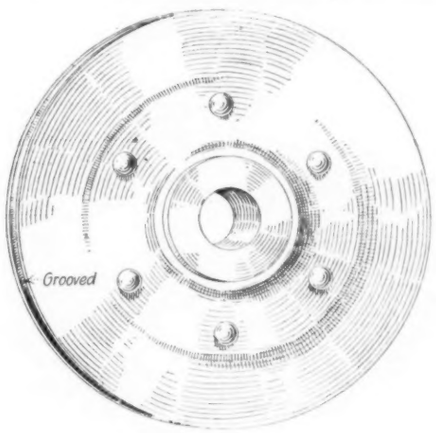
At a bucket speed of 45 ft. per min., each conveyor has a capacity to carry 120 tons of coal per hour. This is just four times the quantity of fuel required by the boilers it serves, and as there are two carriers over each bunker, there should be no difficulty in maintaining a surplus. While the equipment just described differs somewhat in detail from that previously installed, the general plan is practically the same throughout. The system is likely to be duplicated for future units.

Endplay of a Crankshaft may be caused by the crankpin brasses being out of line and bearing alternately on opposite ends of the crankpin, or by the shaft being out of line, causing a wobbling motion of the flywheel, or, in a single-crank engine, by lost motion in the crankshaft bearings.

Steel Elevator Gate Wheels

The elevator gate wheel illustrated herewith is made of sheet-steel disks $\frac{1}{16}$ in. thick, pressed into shape in dies. The disks are hardened and are secured by rivets, as shown, after the hardened steel balls have been placed inside.

The hub is of hardened steel with a groove in the center to receive the balls and form a runway for them. The



ELEVATOR GATE WHEEL

periphery of the wheel is grooved like a sheave, to run upon the edge of a rail.

A little vaseline put in at the start is the lubricant used, and this will require replenishing about once a year. Three stock sizes are made—2, $2\frac{11}{16}$ and 4 in., measured at the bottom of the groove. For flat rails of $\frac{1}{2}$ to $\frac{5}{8}$ or $\frac{3}{4}$ in. wide the wheel is made with a flat face instead of with a groove and is also hardened. It is manufactured by Lewis F. Lyne, 39 Cortlandt St., New York City.

Various Heat-Conducting and Insulating Materials

The following tabulation, compiled by the United States Bureau of Standards and published as Circular No. 55, gives the thermal conductivities in metric units of a number of common materials, also the number of B.t.u. of heat which would pass in one hour through a sheet of the material 1 ft. square and 1 in. thick, with a difference in temperature between the two faces of 1° F. Thermal conductivity in metric units is the amount of heat in calories that will pass in one second through each square centimeter of a plate 1 centimeter thick, if the difference in temperature between the surfaces is 1° C., and is given in column A; the transmission in B.t.u. per hr., per sq.ft., per in., thickness for each degree F. difference in temperature is shown in column B:

Material	A	B
1. Silver	1.0	2,900.0
2. Copper	0.9	2,600.0
3. Aluminum	0.5	1,450.0
4. Iron	0.14	400.0
5. Rock	0.0025 to 0.009	0.7 to 26.0
6. Porcelain	0.0025	7.2
7. Brick	0.002 to 0.005	6.0 to 15.0
8. Glass (ordinary)	0.0016	4.6
9. Water	0.0014	4.0
10. Plaster (ordinary)	0.001 to 0.0015	2.9 to 4.3
11. Wood (hard)	0.0006	1.7
12. Asbestos paper	0.00045	1.3
13. Asbestos felt	0.00025	0.7
14. Sawdust	0.00018	0.52
15. Wood (very soft)	0.00015	0.43
16. Paper	0.00013	0.38
17. Cork board	0.00012	0.34
18. Wool	0.00010	0.29
19. Hair felt	0.00010	0.29
20. Cotton wool	0.00009	0.26
21. Feathers	0.000057	0.16

Cutoff Valves on Low-Pressure Cylinders are used for adjusting and equalizing the work performed by the steam in the high- and low-pressure cylinders.

Gearless Traction Elevators*

SYNOPSIS—An outline of the system, with a general description of the motors, control features and safety devices.

Office buildings and even hotels from 16 to 20 stories and higher require elevators running from 550 to 600 ft. per min. Geared elevator machines are not satisfactory for speeds higher than 400 to 500 ft. per min., and it was to meet the demand for higher speeds that the gearless traction-elevator motor with the rope sheave bolted directly to the armature spider was developed. The traction elevator differs from the ordinary drum-type winding machine in that the ropes are not fastened to the drum; instead, one end is attached to the car. The rope is then passed over the driving sheave, around the countersheave and again over the driving sheave, and the other end is fastened to the counterweight. That is, the traction of the ropes on the driving sheave does the work of moving the car. The system of roping is shown diagrammatically in Fig. 1.

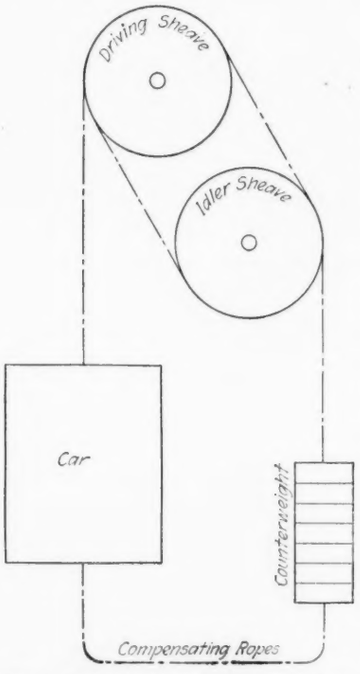


FIG. 1. DIAGRAM REPRESENTING SYSTEM OF ROPING

The gearless, one-to-one traction elevator consists of a slow-speed direct-current motor, a machine of this type running at 64 r.p.m. being shown in Fig. 3, to the armature of which are bolted the brake wheel and driving sheave. The brake wheel and driving sheave are cast in one piece, and the whole machine is mounted on a single bedplate. The construction makes the machine rigid and free from vibration.

The motor is shunt-wound, of the multipolar type, especially designed for elevator service. It is capable of developing the required horsepower and of withstanding temporary overloads of at least 50 per cent. and shocks occasioned by frequent starting under heavy loads. It will operate without sparking, in either direction of rotation, with one fixed position of the brushes at all loads and under all fluctuations of load within its rated capacity.

To use a motor of the highest possible speed, the diameter of the driving sheave should be as small as satisfactory operation of the cables will permit. The smallest allowable sheave diameter for ⅝-in. ropes, which are used for a one-to-one traction, is 30 in. With a motor speed of 64 r.p.m. at normal elevator speed, this size of sheave will give an elevator-car speed of 500 ft. per min.; and a 36-in. sheave a car speed of 600 ft. per min.

The normal load for elevators in this service is generally 2,500 to 3,000 lb. with a maximum of 3,500. A load of 3,500 lb. at 600 r.p.m. with a hoisting efficiency of 80 per cent. requires a 40 hp. motor. The counterweight overbalance is usually 40 to 45 per cent. of the capacity load.

In an office-building elevator installation one machine is usually required to lift safes weighing as much as 6,000 lb. To take care of this the motor is equipped with two brakes, as shown in Fig. 2, and the counterweight is increased. The controller connections are rearranged by closing a knife-switch on the control panel; this rearranges the starting resistance and limits the speed.

A spring-actuated magnetic brake is provided, to stop and hold the elevator under maximum load without shock or jar. The brake consists of a heavy cast-iron wheel of large diameter, cast in one piece with the driving sheave. The brakeshoes are independently pivoted, adjustable and lined with a renewable lining. They are normally pressed against the brake wheel by two independent helical steel springs and are released by an electromagnet. The magnet circuit is opened by all of the various safety

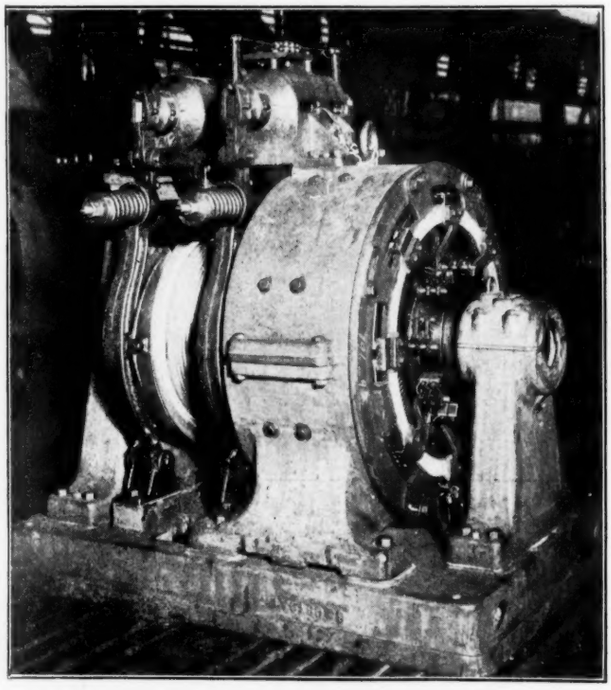


FIG. 2. FREIGHT MOTOR WITH TWO BRAKES

devices, thus insuring the application of the brake at either limit of travel, or if the car attains excessive speed, or if the car is checked in the shaft while descending. The brake is also applied mainly to hold the car when the operator moves the handle to the "off" position or when this handle is returned to the "off" position in the event of the operator releasing it. The switch controlling the brake is arranged to open the circuit on both sides of the magnet coil to insure the application of the brake if grounds or short-circuits occur.

*Compiled from information supplied by the Westinghouse Electric and Manufacturing Co.

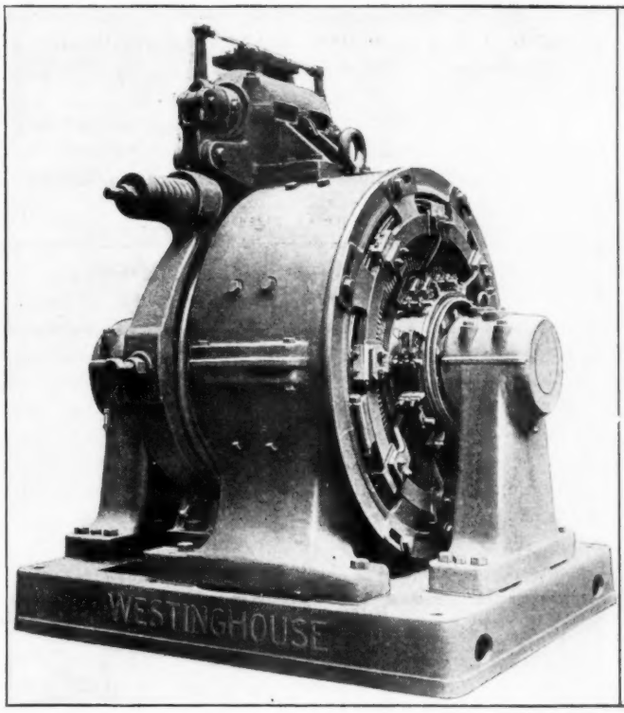


FIG. 3. COMMUTATOR END OF 40-60 HP. 230-VOLT TRACTION ELEVATOR MOTOR

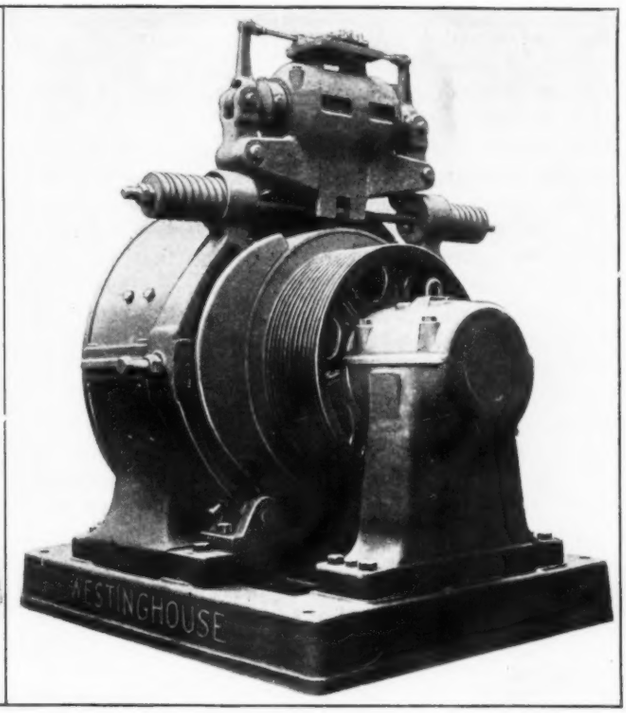


FIG. 4. DRUM END OF SAME MOTOR SHOWING MAGNETIC BRAKE

The safe and satisfactory operation of the elevator depends on the controller and its auxiliary devices, assuming that a reliable and efficient motor has been provided. The control equipment is of the magnetic type, consisting of a switch in the car to operate electrically the control magnets on the controller, Figs. 5 and 6, governing the direction, acceleration, retardation and speed of the car.

No intermediate mechanical devices or mechanical dashpots are utilized to perform any of these operations. The car switch is connected by electric cable with the controller. The motor, controller and rheostat are so

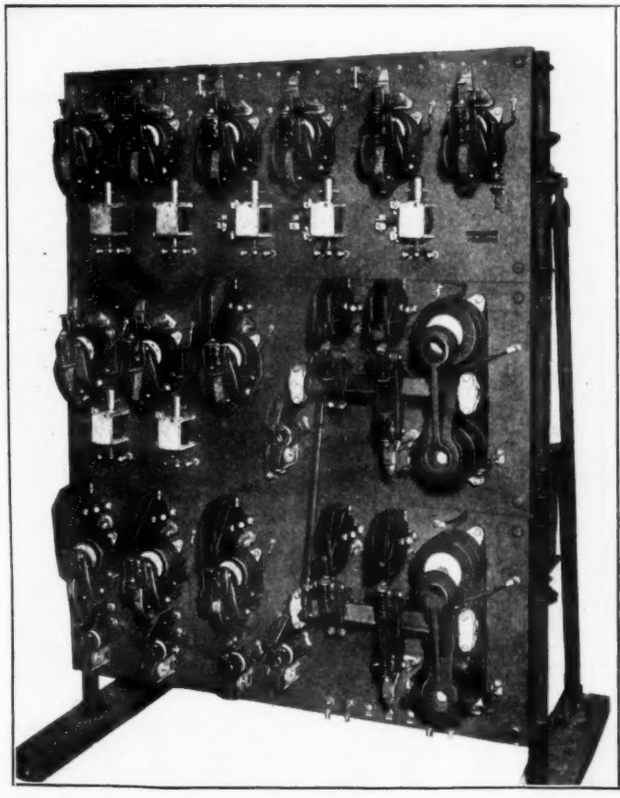


FIG. 5. FRONT VIEW OF CONTROL PANEL

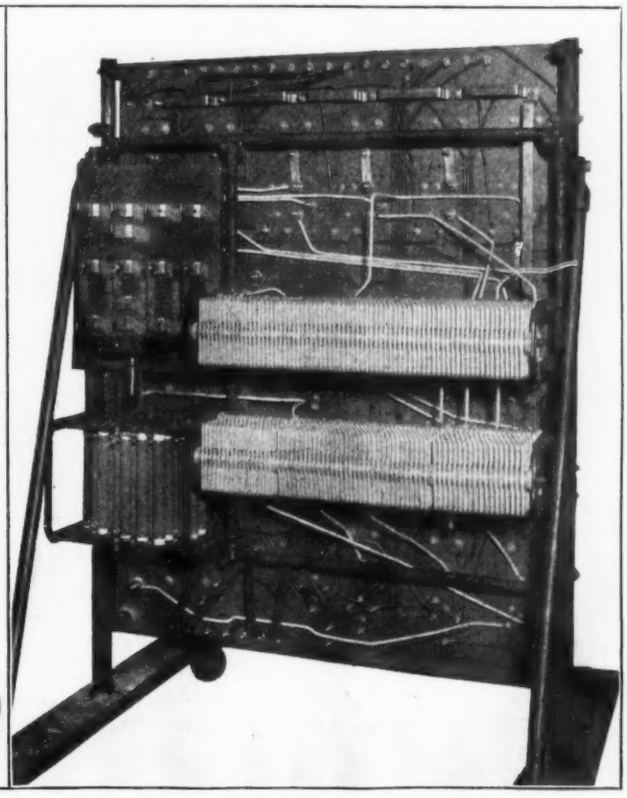


FIG. 6. REAR VIEW OF CONTROL PANEL

designed and arranged that the car is smoothly accelerated and retarded without the initial operation of the brake. A smooth and gradual stop will be obtained without shock or jar. The brake is applied mainly to hold the car at rest when the current is off the motor. The car switch gives the operator complete control for starting and stopping the car, also for operating at various speeds in either direction, and provides for full speed and four lower speeds in each direction. A safety switch is located in the car for opening the line switch upon the control board. This disconnects the motor from the line and operates the magnet switch controlling the dynamic brake. It also disconnects the solenoid on the mechanical brake and applies this brake.

On the face of the control panel are mounted the line and reversing, accelerating and the various speed switches, together with the safety and control devices. All switches are magnetically operated—of clapper type; the contacts meet with a rolling action and, when closed, are pressed firmly together under heavy pressure. The arc is ruptured between copper and graphite contacts, the final contact being made between copper and copper, which gives ample carrying capacity for all conditions of operation. The contact and arcing tips can be easily and quickly renewed.

Functions of the Controller

The starting and controlling resistance and various wiring connections are on the rear of the controller panel. The controller performs the following operations:

(1) It makes and breaks the circuit and reverses the direction of rotation at the will of the operator; (2) the brake circuit is closed on both sides of the coil coincident with the operation of the direction switches; (3) the starting resistance is gradually reduced and finally short-circuited in successive steps in starting the elevator; (4) the motor is gradually accelerated independently of the operator, and after the armature resistance is short-circuited, the relay gradually reduces the field strength of the motor until maximum speed is reached; (5) a relay permits of gradual increase in field strength when the car is slowed down to a minimum running speed on field control. This is under the control of the car operator. A further reduction in speed is obtained by closing parallel armature resistance, cutting in a series resistance and applying the brake. This gradually and quickly brings the car to rest.

The following safety features are provided:

1. The car is gradually brought to rest at either limit of travel independent of the operator. A cam in the hatchway returns the car limit switch to the "off" position. In addition to this, at the extreme top and bottom limit of travel a safety contact is placed in the hatchway and operated by a cam on the car. This contact disconnects the motor from the line and applies the mechanical brake.

2. A safety, or emergency, switch is located in the car, by means of which the operator may stop the car independently of the regular controlling device. This switch is connected electrically to the control panel by a separate cable, so that any accident happening to the regular control cable will not affect its operation.

3. A centrifugal governor in the hatchway is provided with a contact and varies the strength of the motor field by varying resistance in series with the field. This keeps the car from attaining excessive speed.

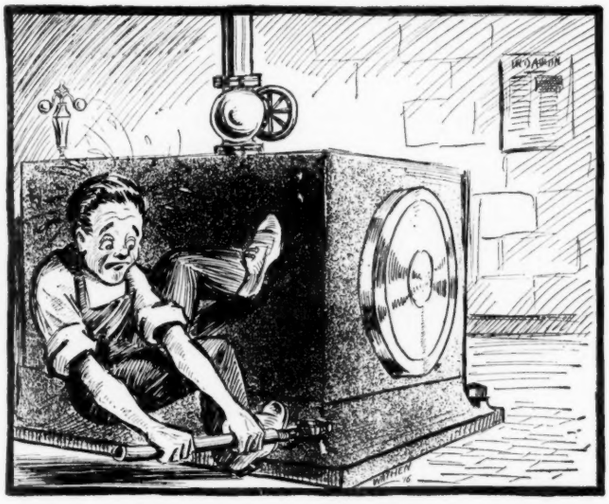
4. An additional contact is placed upon the centrifugal governor, which disconnects the motor from the line at the same time that the safety clutch on the car grips the guard rail in case of excessive speed.

5. Should the electric-power supply fail, an automatic device is provided that will bring the elevator to rest and prevent further motion independent of the hatchway limit stop.

JUST FOR FUN

Wanted the Water Column Down

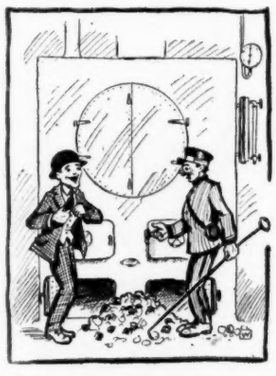
A senior in the civil engineering department of a Western university entered the mechanical laboratories and, gazing at the water column of a testing boiler, asked, "Why don't they put that water column down where an ordinary fellow can see it?"—Harlan A. Russell, Lawrence, Kan.



A PAIR OF "NUTS"

Making Sure of the Water Level

About 4 o'clock one Sunday morning the engineer of a small plant was roused by the watchman, who had walked about two miles to say that he could not get water in the gage-glass although there were two gages of water in the column. The engineer told him to go back and open the gage-glass valves that had been closed and to blow down the water column. He then dressed and went to the plant where he found the banked fire had been drawn and neither water nor pressure showing. The watchman explained that he had opened the gage-glass valves and got 2½ gages all right, but so as to be sure he thought it better to pull the fires. Said he: "I blew her empty and am filling her up again, and I will watch the water come back as she fills and then I'll know it is there."—E. F. Hathaway, Auburn, Mass.



Editorials

Cosmopolitan Engineering

Engineering is a great cosmopolitan profession; its interests are bounded by no city limits, and its opportunities and accomplishments are monopolized by no single community. The modern technical journal gives evidence of this in every issue, if it deals with engineering problems in the slightest degree. Yet there are doubtless provincial minds in the profession which are asking such questions as "What does engineering practice in New York or Chicago mean to me, when the conditions in my plant are utterly different from those in great cities?" and "What does the practice of a little, remote plant out in the Rocky Mountains or the experience of a country station in Maine or Minnesota mean to me, located as I am in the midst of the most intense industrial and financial life on the continent?"

These are fair questions. It is only natural that some readers, looking at an article on prime-mover development for an immense steam-generating station in a metropolis or at a story about substation design for a sub-basement distributing center, will conclude at the outset that no parallel exists between their conditions and those described, and feeling that the financial resources of the big plants put them in a class by themselves, fail to get the most possible out of the published material. Similarly the city-bred engineer may pass too hastily over an account of good things accomplished in a rural station, looking upon the installation of certain new apparatus as a good deal of a makeshift, if not setting it down as crude, rough work.

Engineers with broad insight are quick to appreciate a problem in plant design or operation, whether the station be in the basement of a St. Louis department store or on the shores of a North Carolina river. They recognize the universality of engineering, the great importance of principles and their fit application, and are not hampered by narrow conceptions of merely local affairs. This is why a man with unusually able powers often consents to bury himself in some little hamlet for several years, in responsible charge of some operating situation, content to remain away from the crowded centers until circumstances force his wider recognition. For the same cause another man will delve early and late to "do his bit" in the city-office end of a world-famous project, rejoicing in his connection, even in a minor capacity, with an epoch-making task.

Such men speak a common language, and nothing is foreign to their interest which illustrates the practice of their profession in its higher levels. The engineer of the small steam plant in the country town knows well enough that his employers cannot afford to study a problem of station development in the same way that a metropolitan central station might proceed to lay out an altered plant. The volume of business done very likely is small and limits the amount of money which can justly be expended on investigations. In a general way the approach to such problems may be along parallel lines, but in the great city station the volume of output is so much greater and the total investment is so much larger that it generally pays to spend a larger sum on preliminary work and probably also on the follow-up tasks that lie between the signing of the equipment contract and the acceptance of the completed and tested installation.

Granting that differences in conditions alter methods of problem solution, and even recognizing that many of these methods are incompatible with both city and country application, the fact remains that a knowledge of how difficulties have been met elsewhere is of immense value in the development of good judgment. In some big city stations the visitor from a small-town plant feels almost out of place, so much of the equipment is concealed. There is a certain finality of finish about the installation, a sort of external evidence of everything's having been provided for, of complex organization, which makes the visitor glad to get back to his own plant, where he can see and handle everything in a familiar way. The necessity for a more carefully organized plant explains the difference, and his observations become valuable in due course when the growth of his own station demands more modern development. Similarly, the country plant, often with its homemade devices for saving fuel or water or labor, may suggest to the man with a metropolitan practice an idea that may be applied on a large scale and with every prospect of substantial savings in operation in his own installation.

It is unsafe to assume that practice in one field is without lessons applicable in another, and the engineer who strives ever and always to appreciate what the other man is doing, no matter where he may be located, exhibits the real cosmopolitan spirit which is so potent a factor in sympathetic engineering advance the world over.

The True Engineer

There are some things that test the engineer's loyalty. Here are a few:

The recommendation by himself of his immediate assistant and most-promising understudy for transfer to another department, when such transfer threatens to handicap work in the plant for a considerable period and involves breaking in a new man at a critical time in the plant's development, all because the company needs a competent man in another place.

The request by the general manager for a special report by the first assistant engineer on the behavior of certain auxiliary equipment under his personal observation.

The request by the plant owner that the "chief" work overtime for a week in order to assist the central-station power solicitor to assemble operating data to be used in preparing a proposition for the installation of purchased service.

The supplying by the company bureau of purchase of a grade of inferior lubricants against the advice of the chief engineer, with the request from his immediate superior that he attempt to get the highest efficiency of operation from the undesirable material.

The appointment of an outside engineer five years younger to the post of superintendent of power, the "chief" being retained at a salary increase of $2 per week.

The request of the general manager for a report involving night work for a week in order to complete it by a given date, and the pigeonholing of the report for six months "on account of the unfavorable condition of the stock market" on the day of its completion.

There is no gainsaying the fact that the engineer who can show himself equal to any of these occasions and acquit himself with credit unselfishly proves himself a real man and an honor to the profession.

Who Can Tell?

One is impressed with the progress that has been made in the steam-engineering field by reading some of the engineering books and older issues of technical journals.

Fourteen years ago *Power* had this to say regarding the installation of a steam turbine:

> The center of interest in steam engineering at the moment is at the . . . . where the largest steam turbine yet installed on this side of the water (fifteen hundred kilowatts) and one of the largest yet installed anywhere for electric generation purposes is at work. The outcome of this departure is being watched with intense interest, and upon its success will depend largely the immediate development in the line of the substitution of this form of unit for the reciprocating type.

The successful adoption of the steam turbine is well known. Its popularity has become such that scarcely a power plant of considerable size is equipped with any other type of prime mover.

Today it is not a question of what results will be obtained, but how soon can the unit be got in operating condition and connected to the line? The demand for the output of the machine is such that the plant is scarcely ever completed before the turbine is called upon to produce commercial energy.

Nobody doubts the ultimate results that will be obtained from a turbine when it is shipped to the plant, not even in the thirty and the thirty-five thousand kilowatt units, several of which have been recently built or contracted for. Should the report be circulated that a fifty thousand or a seventy-five thousand kilowatt turbine was to be installed at some large central station, it would not cause much more than a ripple on the surface of the engineering pond. As to its successful accomplishment of the purpose for which it was designed, there would be no doubt at all in the minds of engineers. Such is progress, and thus do we easily become accustomed to the great achievements of the day.

Quite indispensable now in the power plant is the mechanical stoker. It is so common that a hand-fired boiler plant of large capacity is almost a curiosity. Nor are stokers confined to large power plants, for they are quite common in those of two or more boilers ranging from a few hundred horsepower upward. Some stoker installations of the underfeed type are made up of as many as fourteen retorts for one furnace, and there is no reasonable limit to which they could not be extended.

Although so extensively used now it is but a comparatively few years ago that engineers believed that the mechanical method of handling fuel to the furnace would never be a success, owing to mechanical difficulties and to the then assumed fact that it would be impossible to spread the fuel equally over the entire grate area, especially in the corners. Although statements to this effect are found in an engineer's handbook that was quite popular with engineers, they are now so erroneous that they appear ludicrous. The author, however, was undoubtedly honest in his belief and probably expressed the general opinion of engineers regarding mechanical stokers.

Engineering practice is advancing so rapidly in some directions that what seems somewhat visionary today becomes common practice tomorrow. Another instance is boiler pressures. A few years ago the standard was around one hundred and twenty-five pounds. Today it is two hundred pounds per square inch in the large power plants and pressures above two hundred and twenty-five are considered high. A high pressure of two hundred and fifty pounds is being carried in one central station now nearly completed, and that proposed for a new 200,000-kw. power plant now being constructed will be three hundred and fifty pounds working pressure.

Just where the limit to steam pressure will be is a question. With the high pressure mentioned to be used in daily service, and pressures of five hundred and six hundred pounds per square inch being discussed, the end is not yet.

Good reputation is the product of many factors of good judgment.

It is as foolish to assert the absolute decline and fall of the steam engine as it is to conceive of the absolute supremacy of the steam turbine.

Some day New York City will find itself as sick from the smoke nuisance as the boy is after his first cigar—only it will not get over it as quickly.

One of the meanest critters is he who seeks to engage the engineer in argument for the purpose of getting advice he otherwise would have to pay for.

From the bottom of our heart we urge the refrigeration industry to double its efforts in the South and thus make it possible to have something besides pork and grease on the menu.

The fellow in that Boston rubber-hose plant who says he got 83 or 84 per cent. boiler efficiency was likely stretching it.

Some weeks ago we suggested the desirability of having legislative literature edited before adoption. Here are a couple of cases in point:

"*All* fusible plugs shall consist of *a* bronze casting. . . ."

The evident intent is: Every fusible plug shall consist, etc.

"The outside diameter of the plug is to be of the standard pipe threads"???

Correspondence

Heat Maladies of Marine Diesels

Replying to the criticism of my previous comments on two-stroke-cycle oil engines, Mr. Lisle's letter in the May 9 issue makes it apparent that my examples as to repeat orders were inaptly chosen. Since the beginning of the war the European journals have ceased publishing detailed lists as to motor-ship movements, and being requested to cite instances, I was obliged to deduce them from the limited information at hand.

Mr. Lisle evidently overlooked the statement made in my quoted remarks to the effect that during the second trip the Sulzer two-stroke-cycle engines were run over 61 days without mishap of any kind. Since this ship maintained a speed close to its contract speed, certainly not much time could have been consumed in extended shutdowns or repairs en route. The original reference further reports that after covering some 50,000 mi., an inspection showed the working parts of this engine to be in excellent condition. While the 65-day run mentioned by Mr. Lisle is noteworthy, still it is not unusual to specify an uninterrupted 30-day acceptance test for gas-blowing engines and steel-works power machinery.

When perfected as to detail, the engine with the least number of vital working parts is likely best to meet the conditions imposed by severe service. Touching upon this point, the recent paper on "The Marine Diesel and Its Possibilities," by Commander W. P. Sillince, R. N., (Institute of Naval Architects, Apr. 12, 1916) may be quoted in abstract, as follows:

> The marine Diesel engine is essentially an engine of detail. The failure of one or more essential details may involve very serious consequences. Also inaccurate deductions may be drawn from failures of detail.
>
> The first Diesel engines worked on the four-stroke-cycle, and there are numerically many more marine Diesel engines in operation working on this cycle than on the later two-stroke cycle, which dates only from 1906.
>
> A few of the larger engines for cargo-carrying ships work on the two-stroke-cycle principle and develop up to 2,500 b.hp. per shaft—that is, 420 b.hp. per cylinder. The weight per horsepower is about 25 to 40 per cent. less than the four-stroke-cycle engines, and the space occupied is considerably less, especially as regards height. The two-stroke-cycle type is eminently more suitable to the higher powers than the four-stroke-cycle engine.
>
> Generally for naval work, engines having a relatively high speed of rotation, of light weight and occupying as little space as possible are required; and in many special cases these conditions are so vital that failure to comply prohibits their application. Rather more than half of the naval-type engines work on the four-stroke cycle, and the bulk of the latter are not reversible. As might be expected, the larger powers per cylinder work on the two-stroke cycle and are directly reversible.
>
> It may be of interest to refer to two cases of engines installed in the same ship—one a four-stroke-cycle and the other a two-stroke-cycle engine, each running at the same speed, namely, 500 r.p.m., and occupying the same amount of space. It was found that 85 b.hp. was the limit possible with the four-stroke-cycle engine and 125 b.hp. with the two-stroke-cycle engine; the actual weight of the engines was as nearly equal as possible. The ratio of power for equal weight and space was therefore about 50 per cent. in favor of the two-stroke-cycle engine, which is rather surprising in a unit so small.

I would also refer Mr. Lisle to an article by R. G. Skerritt, in the April issue of the *Gas Engine*, relating to a 1,300-b.hp. Fiat oil engine. On the basis of the satisfactory results obtained with this two-stroke-cycle engine, the Brazilian government ordered for its 4,000-ton submarine mother-ship a still larger engine of 2,200 b.hp.

Further development of the two-stroke-cycle oil engine is to be sought in the perfection of its constructive details and in restricting its speed within limits that will allow of easy piston lubrication and prevent cracking of the cylinder parts. A corrected detail often effects a surprising improvement in the performance of a defective internal-combustion engine—so much so, in fact, that the development of any new line of engines consists largely in the gradual elimination of faulty details. History shows that the four-stroke-cycle engine has been no exception to this rule. Mr. Lisle cannot be unmindful of the fact that, starting in 1893, it required almost two years of constant effort to get the first machine to run at all under its own power, notwithstanding that it was of the four-stroke-cycle type.

Mr. Lisle omits to point out just what was the matter with the defective two-stroke-cycle engines he criticizes. These were of large size, and no doubt a considerable portion of such troubles can also be traced back to improper design features that have little or nothing to do with the cycle as such.

What is really needed is unbiased constructive criticism pointing out the nature of any serious troubles experienced during the development period and detailed defects. After both the two- and four-stroke-cycle types of marine oil engines are thoroughly perfected for a variety of purposes, it will no doubt be found that each type has applications to which it is particularly adapted.

The time for making this decision is not yet. It is generally conceded that a perfected type of two-stroke-cycle oil engine offers a number of marked advantages, and whether or not an engine of this type will ultimately be evolved that will make good this promise in every respect, time alone can tell, and time is no less essential to develop the possibilities of the two-stroke cycle than it was in the case of the four-stroke cycle.

Milford, Conn. LOUIS ILLMER.

Unfulfilled Guarantees

The editorial, "Unfulfilled Guarantees," in Apr. 4 *Power* reminds one of the fact that intelligent purchasing is very essential to the success of any power plant. If every concern had men that were capable of purchasing intelligently, manufacturers would soon cease to ship goods that would not fulfill guarantees.

Generally the salesmen are able to form an accurate opinion of the purchasing agent's ability, after a short conversation with the latter. An instance was where a large compound engine was purchased. The representatives of two well-known manufacturers were on hand

to demonstrate the good qualities of their respective machines, and from detailed explanations of the features of each machine it really seemed like a toss-up which machine should be purchased. The agent finally decided in favor of the salesman that showed him the best steam-consumption guarantee. The salesman that received the order waited until his competitor had gone, then he called the purchasing agent to one side and confidentially told him that he would rather guarantee a steam consumption a couple of pounds in excess of the guarantee that he had already given and be able to meet it, than to give him a guarantee that he was not quite sure of. The purchasing agent stood for the change. Evidently this salesman had his man well sized up.

Binghamton, N. Y. J. A. HAWKINS.

If you should publish in more detail the data on which your editorial is based, we believe you would be performing a service the value of which would be hard to estimate, not only to users of this type of apparatus, but also to its manufacturers.

Within the last six months we have had reported to us tests on fourteen pieces of apparatus indicating that the guarantees made on them had not been fulfilled. All of these except one were in installations made by cities. We find that at least 95 per cent. of the apparatus bought by cities is carefully tested. Probably only 5 per cent. of the apparatus sold to industrial concerns is tested.

It is to the interest of everyone concerned—except possibly the unprincipled manufacturers or the manufacturer who is ignorant of the results he can obtain on his apparatus—to make more general the practice of testing apparatus to find if the guarantees made are lived up to. I believe the publication by you of a few well-chosen tests to illustrate the rather prevalent failure of some manufacturers to fulfill guarantees made on apparatus sold to cities would influence the engineers and managers of industrial concerns to insist upon either a well-conducted test in the shop of the manufacturer before shipment or a similar test after installation, or both. J. D. BERG.

Pittsburgh, Penn.

The Hall of Records Test

In the issue of Apr. 25, A. T. Rogers presents an interesting study based upon some parts of the reports and computations of the Hall of Records test which have been made available for his observation. He criticizes my estimate of the economy in fuel that will result from the anticipated cessation of operation of the electrical generating engines. His own estimate is another interesting contribution, but the real conditions are readily and definitely determinable by the simple process of trying them, which was the purpose and intent of the test, only one-half of which has so far been undertaken.

If all the facts had been before the readers, they would explain some points in my estimate to which Mr. Rogers refers. I am not responsible for the figure of the contribution to house-heating work provided by the engine exhaust. The amount, 11,250,956 lb., was determined by the test engineer, Dr. Herman Diederichs. The quantity of exhausted steam is not the same as the amount that was supplied as live steam to the engines—namely, 36,275,352 lb., but is less by the proportion of foul drips due to cylinder condensation, which was determined by the test engineer to be 8,679,400 lb. The exhaust steam from the engines available for heating was thus only 27,595,950 lb., of which about 40 per cent. was utilized. The following savings would be effected by shutting down the engines:

	Pounds
1. All the live steam heretofore supplied to the engines less the utilized exhaust (contributed by the engines and having to be replaced by live steam) net	24,024,396
2. A reduction in the condensation in the high-pressure piping, by the disuse of the main pipe line and branches. I estimated this at only 57 per cent. of that attributed to the engines by the test engineers, or	2,600,000
3. A reduction in the condensation of exhausted steam, by the disuse of the large underground pipe line and branches, leaving that amount of exhausted steam available for heating purposes. I estimate this at the conservative figure of	200,000
4. A reduction in the use of exhausted steam by feed heating, leaving a large proportion available for house heating. This I figured, and found to be about	1,000,000
5. A reduction in the use of feed pumps and drip pumps, which may be considerable, but which I assumed under municipal methods might be only	200,000
Total saving, or reduction in steam to be generated	28,024,396

This leaves 52,632,467 lb. that may have to be provided. Like Mr. Rogers I am unable to follow the city engineers' ratiocinations and involved mathematics, nor can I accept as reasonable the methods of computation of the engineers advising the bureau.

The facts, however, are so plain and simple that I believe any ordinary person may understand them very well and may be inclined to agree with me that the lost time of the past two years would have been better spent in testing out the results of the change rather than in those endless convolutions of controversial computations.

In further response to Mr. Rogers' inquiries it should be noted that the feed heater in this plant is located in the line from the machinery to the house-heating system and therefore may not only absorb exhaust steam before it gets to the house, but may receive part of the reduced-pressure live steam from the house system. Thus savings due to lessened feed-heating and to lessened exhaust-line condensation are warranted by the circumstances.

I am glad to note Mr. Rogers' interest in the elevator plant, though I think upon reflection he will conclude that his suggestion of using elevator water for condensing purposes is not practical. The question of the adoption of hydraulic elevators in his new building may be cleared by the facts derived from the operation of the hydraulic power plant in the Hall of Records. The consumption of steam averaged over the year no less than 796 lb. per car-mile, and with the share of auxiliaries and other losses aggregated 1,004 lb. to the mile. The cost of fuel, after making full deduction for exhaust utilized in heating work, was 12.88c. per car-mile.

The net cost of the power in fuel, labor, repairs and supplies was 35.3c. per car-mile, and with fixed charges and superintendence, it aggregated 42c. per car-mile.

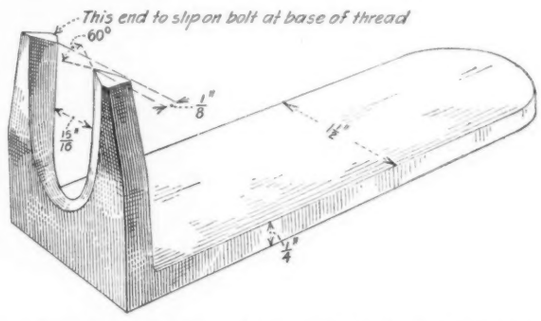
Modern electric elevators could have been operated in this building at a cost for purchased power of less than one-fourth of the cost of hydraulic operation.

The suggestion that electric elevators may be operated as a helpful addition to the load of electric generating engines is qualified by the disadvantage that elevator loads are so variable that the rate of steam consumption becomes excessive, and its erratic character is not well suited to heating demands or to the maintenance of steady lighting. REGINALD P. BOLTON.

New York City.

Putting Caps on Headers

When putting on the header caps of Babcock & Wilcox boilers, it is sometimes inconvenient to hold the bolt and inside safety clamp in position until the outside cap and nut are placed on the bolt. This may be avoided and the work made easy by using a tool, as shown, which can be slipped on the bolt at the base of the thread to



TOOL FOR HOLDING BOILER HEADER CAP BOLTS

hold it wherever desired until the outside cap and nut are placed on the bolt.

The work can be done rapidly by first putting in all of the inside safety clamps and bolts. While the workman is then using the tool to hold them in position, his helper can hand him the cap and nut, which can be tightened slightly. Afterward they can all be gone over with a wrench and made tight. C. E. Kling.

Philadelphia, Penn.

The Value of Cylinder Oils

In the letter by C. E. Carpenter in the Apr. 11 issue, page 519, he says that engineers do not give sufficient consideration to the selection of cylinder oils, and that it is all so simple.

Mr. Carpenter also claims that the adhering property of cylinder oil is the really important one. He condemns the fire test as amounting to nothing and calls the viscosity test a humbug. Just what is this adhering property and how can it be determined?

I wish Mr. Carpenter would give us some of his reasons why the viscosity test of cylinder oil amounts to nothing.

Medford, Mass. George B. Longstreet.

Operating Economizers at Reduced Pressure

George H. Diman's article in the Apr. 25 issue regarding the reduction of pressure on economizers merits some thought. In plants where the water enters the economizers at a low temperature and is raised to, say, 235 deg., which would be possible at the 10 lb. pressure mentioned by Mr. Diman, it would be practical from a heat standpoint to operate the economizer at a reduced pressure. If, however, the plant has feed-water heaters that raise the temperature to 200 deg. or better, then pass this water through an economizer raising the temperature to 300 deg. or more, the matter now takes on a different aspect. Then it becomes necessary to maintain a pressure higher than that at which the water will evaporate, which of course eliminates any chance of operating the economizers at a low pressure.

The use of two feed pumps handling the same water would seem to be undesirable from the standpoint of added equipment and increasing chances of shutdown, but no doubt these objections are offset by the gain Mr. Diman derives from the increased temperature of the feed water and the freedom from shutdowns due to economizer failures at high-pressure operation. L. M. Hadley.

Springfield, Ill.

A Trip with the Inspector

The writer, an insurance inspector, recently examined a boiler in a state having no inspection laws, and, after preparing a report for the insured, decided that some of the data and conditions of the boiler copied from the report might be of interest to engineers and boiler inspectors.

At the time the boiler was insured, I was spending a few days at home before starting on a long trip, and knowing the conditions in the state where the boiler was located, decided that the time was ripe for an inspection even though the expense was considerable.

Arriving at the plant, I found everything supposedly ready for internal inspection—boilers hot, top manhole plates not removed, combustion chambers full of fire and wood ashes, and the "engineer" sitting on a lumber pile sunning himself, waiting for me. I walked through the boiler yard—not house, for there was practically no house over the boiler—looking for a place to change my clothes and saw a bolt sticking in the front head of the boiler. Upon asking the engineer what it was for, he replied, "Some fool boiler inspector hit the boiler with a hammer and put a hole in it, and he had to stop it up with a bolt."

I found the blacksmith shop, which in these Western mountains is not a very warm place in the winter, hung my clothes on a stick screwed up in a vise, slid into my overalls and proceeded to inspect and take data. The following is from my notebook:

Shell length 16 ft. 6 in., diameter 40 in., courses 4, age 30 years. Thickness of shell $\frac{9}{32}$ in., thickness of heads ½ in., longitudinal joint, double-riveted lap, pitch of rivets 2½ in., rivet hole ¾ in. Top stays, head to shell, five ⅞-in., round, welded iron; front head, four of the same type. Stays below flues, none. Dome, 24-in., flat head, two ⅞-in. welded iron rods from head to shell. Feed, ¾-in. top of shell, discharge bottom rear end. Safety valve, 3-in., ball and lever, set at 65 lb. Blowoff, none; handhole used instead. Flues, two, sections 5, diameter 12 in., thickness of sheet $\frac{9}{32}$ in. Joint in sheet, single-riveted lap, pitch of rivets 2-in., rivet hole ¾-in.

Defects: Steam gage inaccurate, shell seriously corroded, side walls falling, iron band hangers for boiler nearly burned in two, no blowoff pipe or hole for one; one broken stay to front head, two broken stays to back head, and two in the dome; bag 6 in. deep and about five years old at the rear end of the shell; front head deteriorated considerably, owing to external corrosion and leaky handhole plate; boiler hanging in two bands passing under shell to overhead timbers, size of bands ½x3 in.; also, a number of other small defects.

After I had finished the inspection, the engineer asked if I considered the boiler good for 100 lb. pressure. When I replied negatively, a bystander, the ex-engineer,

remarked: "Now, young fellow, that's where you so-called experts don't know as much as us old engineers. I fired that boiler and carried 110 lb. pressure on it, and it didn't blow up." The mildest reply I could think of was that Hell was full of smarter men than he, sent there by better boilers than that one.

There was no door in the combustion chamber, and it took considerable argument to get the engineer to tear down the end wall, which was only 8 in. thick. He argued that there could be nothing wrong in there and bricks cost 5c. each. After I came out, the engineer said, "Well, what do you say, now?" I replied, "The boiler is bagged, and I'm blistered." The superintendent, a fat good-natured Celt, put in, "Yes, and the seat of your breeches is on fire to boot." However, he took me up to the Lumber Jack Hotel, "blew" me to a good dinner and promised to replace the condemned boiler with a new one.

R. S. HART.

Spokane, Wash.

The Danger of "Just Fooling"

Why do engineers with a full understanding of their responsibility allow fooling or practical joking in the plants? I am strongly against it and believe it merits dismissal. Therefore I have made it a point to discourage those so inclined and have found no trouble in doing this after once showing them that their pranks would not be tolerated.

The fellow that monkeys with the safety devices, or for that matter with anything that may endanger another's life, is a criminal and should be treated as such. He is therefore a mighty poor man to have around a plant and his chief is almost as bad.

I once saw a watch engineer and a head repairman having a friendly wrestling match within three feet of a large unguarded flywheel turning about 150 r.p.m., and it must have delighted the fool killer. I know an engineer who dropped a 24-in. Stillson wrench from the third deck of a vertical air compressor to the ground floor, with the idea of scaring a young oiler. Unfortunately, his aim was not good and the wrench struck the low-pressure crank just as it came to the top quarter, and it went sailing across the engine room into the center of a newly installed marble gage panel.

An electrician wired up the brass guard rail around a motor set, the idea being that a ground would be formed if anyone standing on the iron floor put his hand on the rail and that he would get a shock. It worked all right, but the owner of the plant was the first and only one to get the benefit of this ingenious scheme for saving brass polish. Shortly after this we had a new electrician.

All in all, it does not pay to forget for even a minute that your work in a steam plant is a man's work and should be treated as such.

ARTHUR D. PALMER.

Dorchester, Mass.

Evaporation Tests with Different Fuels

Noticing the interest in boiler tests taken by *Power* readers, I present herewith three evaporation tests of different fuels carried on under the same boiler, a horizontal-tubular having 33 sq.ft. of grate surface. Observe the comparatively poor showing of coke. Owing to the porosity of the fire and its sensitiveness to draft, it was necessary to keep the individual damper one-half open. This demonstrated that the grate area was too large for the fuel.

Comparative evaporation tests made to determine the fuel best suited to our purpose, using a shaking grate and a blower, gave results shown in the table below. Because in recent years considerable effort has been made in burning coke breeze, the figures given are interesting.

	Coke	Anthracite Screenings	Coke Breeze
Weather	Partly cloudy	Rainy	Fair
Duration of test	8 a.m.-4 p.m.	8 : 45 a.m.-4 : 45 p.m.	8 a.m.-4 p.m.
Average steam pressure, lb.	105	105	105
Draft: Stack, vac.	0.27 in.	0.25 in.	0.30 in.
Draft: Uptake, vac.	0.26 in.	0.29 in.	0.28 in.
Draft: Furnace, vac.	0.06 in.	0.07 in.	0.07 in.
Draft: Ashpit, pres.	0.09 in.	0.65 in.	0.65 in.
Average temperatures:			
Air in fireroom, deg. F.	62	60	50
Feed water, deg. F.	54	46	45
Gas at uptake, deg. F.	514	502	572-622
Combustion chamber, deg. F.	1,665	1,483	1,740-1,900
Fuel:			
Total weighed, lb.	5,050	9,600	7,035
Total on floor at end of test, lb.	901	4,585	489
Total as fired, lb.	4,149	5,015	6,546
Moisture in, as fired, lb.	385.86	191	1,348.48
Total weight dry, lb.	3,763.14	4,824	5,197.52
Total weight of ash and refuse, lb.	295.00	1,320	1,345.00
Percentage of ash and refuse in dry fuel.	7.8	27.3	20.54
Heat value per lb., B.t.u.	12,920	12,646	12,442
Horsepower developed	1,054.21	866.81	1,292.8
Rating, percentage	133	109	166
Economic results:			
Water apparently evaporated per pound of, as fired, lb.	7.25	4.9	5.63
Equivalent evaporation per pound of, as fired, lb.	8.76	5.86	6.81
Equivalent evaporation per pound of dry fuel as fired, lb.	9.93	6.19	8.58
Actual equivalent evaporation per pound of combustible as fired.	10.48	8.54	11.56
Efficiency of boiler, per cent.	78.63	60	90
Efficiency of boiler and grate, per cent.	65.09	73	53

Cambridge, Mass.

BALDA E. A. BORENZI,
Chief Engineer,
Cambridge Gas Light Co.'s Plant.

Quoting Prices and Discounts

Some wonder why certain engineers do not purchase the supplies for their plants. One of the obstacles is the system of prices and discounts in vogue.

For example, I called on the phone for the price on a 2½-in. atmospheric relief valve and was told to wait a moment; then I heard, "What sheet is the ——— on?" After being told a letter of the alphabet, the supply man began hunting through some book, and in about five minutes he told me it was 62, two 10's and 2½ per cent. off. "You have our catalog down there and the list price on the valve is $12.25; you are entitled to a discount of 62, two 10's and 2½." So I figured the discount like this: List $12.25 — 62 per cent. = $4.655 — 10 per cent. = $4.19 — 10 per cent. = $3.77 — 2½ per cent. = $3.678, net price. I began to wonder why one or two discounts wouldn't do, so took the same valve with 70 per cent. off and got $12.25—70 per cent. = $3.675 as the net price.

I wish someone would tell me the reason for all this foolishness. Why are half a dozen discounts, some of them fractional, used? Personally I cannot see why two, and in a great many instances one, will not fit any case.

The engineer that is unfamiliar with discounts is placed in an embarrassing position with his employer, who wants net costs and not lists and discounts. Besides, there is a great deal of time wasted in getting quotations and checking invoices. A system with fewer discounts would assist the engineer and help the supply houses to cut their overhead expenses.

Kansas City, Mo.

H. G. SCHULER.

Inquiries of General Interest

Quick Kindling of Buckwheat Coal—In firing free-burning No. 1 buckwheat coal with a forced draft, in order to get the fire to burn up quickly and evenly is it better to spread the bright spots over small dead places with a poker or to allow the fire to burn up and spread of its own accord? H. A. N.

Better results would be obtained by letting the kindling spread of its own accord, and a still better method is to cover the bright spots with fresh coal.

Control of Speed by Flywheel and by Governor—Is the speed of an engine controlled by the governor or by the flywheel? P. S.

When the speed of rotation tends to vary during the period of a single revolution, owing to variable turning effort on the crankpin or to sudden change of load, the variation is regulated by the flywheel. When, however, the variation from normal speed is in the nature of a gradual increase or decrease of speed, extending over a number of revolutions, the speed is controlled by the governor.

More Rapid Steaming with Smaller Sizes of Coal—Which will generate steam more rapidly, large-sized or small-sized coal? H. C. D.

With a given size of furnace and draft sufficient for equally perfect combustion, the smaller sizes of coal will become burned and will generate steam more rapidly than the larger sizes. The more finely divided the more promptly are the combustible elements of the fuel raised to the temperature of combustion and sooner brought in contact with the oxygen of the air supply, resulting in more rapid combustion and a quicker liberation of heat than from combustion of larger sizes of coal.

Variable Turning Effort of Reciprocating Engines—What are the sources of variable turning effort in the crankshaft of a reciprocating engine? W. D.

The causes that produce variable turning effort are: The variable pressure of the steam acting on the piston; the mechanical combination of crank and connecting-rod which, even with a uniform steam pressure on the piston, results in a variable turning effort on the crankpin ranging from zero to a maximum, twice during every revolution of the crank; and the inertia of the reciprocating parts of the engine including the piston, piston rod, crosshead and connecting-rod, which absorb power in acquiring velocity during the earlier part of the stroke and restore it while being retarded during the latter part of the stroke.

Heat Value of Coal—What is the heat value of a coal whose composition is carbon, 74.79 per cent.; hydrogen, 4.98 per cent.; oxygen, 6.42 per cent.; nitrogen, 1.2 per cent.; sulphur, 3.24 per cent.; water, 1.55 per cent.; incombustibles, 7.82 per cent.? R. H.

The heat value may be computed by Dulong's formula,

$$\text{B.t.u. per lb.} = 146C + 620\left(H - \frac{O}{8}\right) + 40S$$

in which C, H, O and S are respectively the percentages or parts in 100 of carbon, hydrogen, oxygen and sulphur. Substituting in the formula,

$$\text{B.t.u. per lb. of the coal} = (146 \times 74.79) + 620\left(4.98 - \frac{6.42}{8}\right) + (40 \times 3.24),$$

or 13 639 B.t.u.

Slide-Valve Engines Require More Clearance—Why is it necessary for a slide-valve engine to have more clearance than a Corliss engine? L. B.

With a slide valve the cylinder steam passages must be longer and more waste clearance space is necessary than for valves of a Corliss engine, wherein shortness of admission and exhaust passages is obtained by placing separate steam and exhaust valves close to the ends of the cylinder. Horizontal slide-valve engines are not as well adapted to prompt drainage of water from the cylinders as horizontal Corliss engines, for in the latter the exhaust valves are placed at the bottoms of the cylinders and during the flow of steam from the cylinders the exhaust surfaces are swept clear of water and the more perfect drainage which is thus provided makes less piston clearance necessary to prevent smashing from the presence of water.

Type of Longitudinal Joint Required—What style of joint would be required for the longitudinal seam of a cylindrical boiler shell 40 in. diameter to carry a pressure of 100 lb. per sq.in., with a factor of safety of 5, if the thickness of the plate is ¼ in. and the tensile strength of the plate is 55,000 lb. per square inch of cross-sectional area? C. H.

As the shell exceeds 36 in. diameter, to conform with good practice and the provisions of the A. S. M. E. Boiler Code for high-pressure boilers, the longitudinal joint should be of butt and double-strap construction. With a factor of safety of 5 each inch length of the longitudinal joint should be capable of resisting a stress of $5 \times (100 \times 40) \div 2 = 10{,}000$ lb. The solid plate would be capable of resisting, across 1 in. of length of the shell, a stress of $1 \times \frac{1}{4} \times 55{,}000 = 13{,}750$ lb. Therefore the efficiency of the joint would need to be at least $10{,}000 \times 100 \div 13{,}750 = 72.7$ per cent. This is well within the efficiency of a properly-designed butt and double-strap joint, double-riveted, and that type of joint could be employed.

Characteristics of Squirrel-Cage Induction Motor—Does the rotor of a squirrel-cage induction motor run at synchronous speed, if not, is the slip dependent on the resistance of the rotor, and is no torque developed at synchronous speed? C. A.

The rotor speed of a squirrel-cage induction motor is always less than synchronous speed. The rotor must revolve slower than the stator magnetic field for a current to be set up in the rotor conductors to produce torque. The difference between the speed of the rotor and that of the magnetic field is called the slip of the motor.

With a given load the slip will be proportional to the resistance of the rotor bars and end rings. On well-designed motors this amounts to about 2.5 per cent. on large motors and about 8 per cent. on small-sized machines.

No torque will be developed at synchronous speed. At this speed the motor is running at the same speed as the magnetic field, therefore no current will be set up in the rotor conductors.

Working Pressure for Firebox of Vertical Boiler—What is the formula for the allowable working pressure for the furnace of a vertical fire-tube boiler having screwed and riveted stay-bolts, and what allowance is made for strength due to the cylindrical form of the firebox sheet? C. H.

The cylindrical form is not considered to incorporate any added stiffness, since the pressure on the convex side tends to produce collapse. Hence the furnace wall is to be stayed as if it were a flat plate. According to the A. S. M. E. Boiler Code, the maximum allowable working pressure for various thicknesses of braced and stayed flat plates and those which require staying as flat surfaces with braces or stay-bolts of uniform diameter, symmetrically spaced, shall be calculated by the formula:

$$P = C \times \frac{t^2}{p^2}$$

where

P = Maximum allowable working pressure in pounds per square inch;

t = Thickness of plate in sixteenths of an inch;

p = Maximum pitch measured between straight lines passing through the centers of the stay-bolts in the different rows, which lines may be horizontal, vertical or inclined, in inches;

C = 112 for stays screwed through plates not over $\frac{7}{16}$ in. thick with ends riveted over, or 120 for stays screwed through plates over $\frac{7}{16}$ in. thick with ends riveted over.

The code also provides that in a vertical fire-tube boiler the furnace length, for the purpose of calculating its strength and spacing stay-bolts, shall be measured from the center of rivets in the bottom of the water-leg to the center of rivets in the flange of the lower tube sheet; and also that when the longitudinal joint of the furnace sheet is of lap-riveted construction and stay-bolted, a stay-bolt in each circular row shall be located near the longitudinal joint.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Increasing Thermal Efficiency of Automobile Engines*

By C. E. Sargent†

SYNOPSIS—An analysis of the losses in a throttle-controlled gasoline engine with suggestions for increasing the thermal efficiency by increasing the compression inversely as the load. Although written primarily with the automobile engine in mind, nevertheless it is fundamental to all throttle-controlled gas or gasoline engines and therefore will be of interest to operators of such stationary engines.

To properly comprehend the problem of increasing the thermal efficiency of internal-combustion automobile engines reference will be made to Fig. 1, which shows 20 per cent. of the heat converted into useful work and 80 per cent. lost or rejected in friction, cooling water, radiation and exhaust. To convert more heat into work it will be necessary to decrease one or more of these losses, all of which are characteristic of internal-combustion engines. With good workmanship, force-feed oiling and light reciprocating parts, the mechanical efficiency is about as high as can be expected, namely, 95 per cent.

The loss of heat to the water jacket depends on the difference in temperature between the burning gases and the cylinder walls, the time the cylinder walls are exposed to the heat of the flame and the surface exposed. The time per working stroke in which the difference of temperature exists is cut down by high speed, wherein lies the advantage of high piston speed in an engine of this type.

Even with a spherical explosion chamber the ratio of the surface to the heat within decreases with compression, therefore the higher the compression the less cooling surface per unit of heat exposed. The limitation of high compression is of course premature ignition, a condition incompatible with successful operation.

The possibilities of increasing the thermal efficiency by decreasing the jacket losses lie then in a high piston speed, a minimum surface per unit of volume characteristic of the sleeve valve and the valve-in-the-head types, and as high a compression as possible without the possibility of spontaneous ignition.

While small gains in efficiency have been made by reducing the mechanical friction and decreasing the losses to the water jacket, the loss of heat to the exhaust has had but little consideration. Several compound internal-combustion

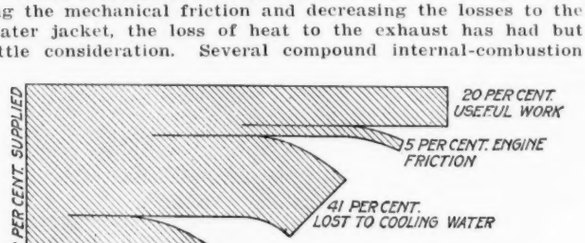

100 PER CENT. SUPPLIED
20 PER CENT. USEFUL WORK
5 PER CENT. ENGINE FRICTION
41 PER CENT. LOST TO COOLING WATER
34 PER CENT. REJECTED IN EXHAUST AND RADIATION

FIG. 1. DISTRIBUTION OF HEAT TO ENGINE

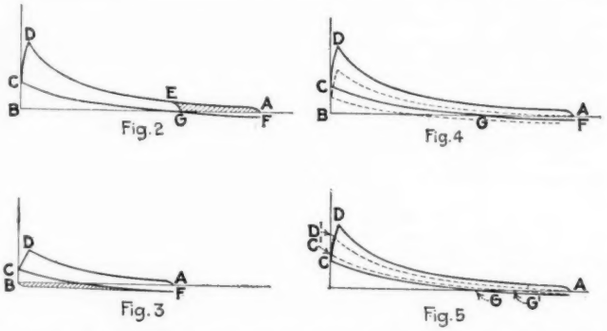
engines have had a mushroom existence, but when one considers the added surface of a larger cylinder and the time in which the pressure after ignition drops to less than the pressure of compression, the improbability of reducing the losses by this means is apparent.

The ordinary engine is more efficient at full load than at partial load, but unfortunately the automobile engine operates at partial load most of the time; therefore, if we would increase the brake horsepower per unit of fuel or the miles per gallon, it should be so designed that its thermal efficiency is greatest with average or partial loads.

It is necessary to open the exhaust valve from 40 to 60 deg. before the end of the working stroke in order to get rid of the back pressure on the piston during the exhaust stroke. The release of this pressure at 30 to 40 lb. absolute, with its accompanying "bark," visible flame and red-hot exhaust manifold, is ample evidence of thermal inefficiency.

If the expansion of the burning charge be carried 50 per cent. farther, releasing the gases at a lower pressure, at a lower temperature and at a point nearer the end of the working stroke, more heat will be turned into work, because less will be rejected in exhaust, less power will be required to open the exhaust valves, and the function of the muffler will become extinct.

Fig. 2 shows a full-load diagram of an engine carrying the expansion 50 per cent. longer than the compression stroke, in which AB represents the length of cylinder and atmospheric pressure. The piston, starting at B, draws in a charge to G, when admission is closed, and the absolute pressure in the cylinder drops to F when the piston reaches A at the end of the stroke; FC represents the compression line, which crosses the atmospheric line at G. With the same clearance as an engine having a stroke BG, the compression BC, the firing line CD and the expansion line from D to E, with the same mixture and timing, would not vary from those of the ordinary engine, but the shaded area of the diagram EAG would represent the gain in power, using the same amount of fuel, by expanding 50 per cent. more than the induction stroke.



FIGS. 2 TO 5. ILLUSTRATING GAIN THROUGH EXTENDING EXPANSION

The shaded part of the diagram averages 16 to 20 per cent. of the whole, indicating a 20- to 25-per cent. increase in thermal efficiency, or a corresponding increase in power from the same amount of fuel. An engine using such a cycle may weigh a little more per horsepower output, just as a long-stroke motor is heavier than one with a square cylinder and, on account of the long stroke per pound of mean effective pressure, may have more mechanical friction, but while the cooling surface per heat unit introduced is increased, the difference in temperature during the last third of the working stroke is so slight that an additional transfer of heat seems improbable.

The average heat balance of five full-load tests from a 50-hp. 10x20-in. engine, cutting off at about two-thirds its stroke, using the high value of fuel, is as follows: Thermal efficiency on b.hp., 26.02 per cent.; engine friction, 4.86 per cent.; radiation and exhaust, 22.59 per cent.; water jacket, 46.48 per cent. Of course this high efficiency would be obtained only at full load or with an open throttle.

With advanced ignition and a throttled mixture with its low compression, the terminal pressure will approach atmospheric, but the loss from wiredrawing and the low compression is probably more serious than the exhaust-gas losses at full load.

Fig. 3 is a diagram from an engine developing partial load with the ignition advanced to compensate for the slow-burning mixture, in which AB represents the atmospheric line and the piston travel, BF the rarefaction during the induction stroke, FC the compression, CD the firing and DA the expansion line. The shaded part shows the back pressure or loss in every cylinder during the partial load. As the area of the shaded part of the diagram, or the negative load, must be offset by a like amount of area above the atmospheric line, the fuel consumption of an idling engine is necessarily great.

*From a paper, before the Indiana Section, Society of Automobile Engineers.

†Chief engineer, Lyons-Atlas Co.

Tests have demonstrated that an engine driving a car on a smooth road at 20 mi. per hr. will require no more fuel than when idling at the same speed. Every engine whose speed is regulated by the throttle opening develops a negative load, which must be overcome by an equal positive pressure before it will deliver available power. This negative load decreases with a wide-open throttle, a condition, however, seldom obtained.

The loss from low compression caused by a greater surface for heat absorption per unit of volume is not shown on the diagram, but appears when a heat balance is obtained.

As the load becomes lighter, the compression less and the mixture weaker from having a larger percentage of carbon dioxide, the inflammation is necessarily slower, and the desirability of an earlier ignition is apparent if the maximum efficiency under adverse conditions is desired. The ultimate solution of the timing problem for our present motors, in the author's opinion, is to automatically advance the time of ignition directly as the speed and inversely as the load.

To prevent the wiredrawing loss shown in Fig. 3, closing the admission valves earlier instead of throttling the mixture will reduce the mean effective pressure, without creating a back pressure and eliminate light-load losses except those indigenous to low compression.

Carburetors properly designed for efficiency should provide a weaker mixture as the compression increases. A mixture too weak to ignite at atmospheric pressure will fire and do work if sufficiently compressed. A rich mixture is necessary in starting and with partial load, because the exhaust product content being constant and the compression less, the combustible molecules are not sufficiently close for proper chemical action, therefore there should be more of them in the same space to get rapid and efficient firing.

QUALITY AND COMPRESSION

Blast-furnace gas having a heat value as low as 90 B.t.u. per cu.ft., making 45 B.t.u. when mixed with a like amount of air, will not burn at atmospheric pressure, yet is an ideal fuel when compressed to 180 lb. Also, air containing less than 50 B.t.u. of gasoline vapor per cubic foot will not burn at atmospheric pressure, but when compressed sufficiently, will fire and do useful work.

The higher the compression, other things being equal, the greater the thermal efficiency, yet the compression must be below the critical point of premature ignition. If the mixture is weakened as the compression increases, the relation of the combustible molecules will remain constant, maintaining practically the same rapidity of inflammation.

If a motor is designed to give a maximum compression and full rated load at two-thirds cutoff, as shown in full-line diagram (Fig. 4), a better efficiency will be obtained at full load than is obtained in the ordinary automobile engine, because less heat is exhausted and more turned into work.

It already has been shown that if the point G is moved toward B as the load gets lighter, there will be no loss from wiredrawing, but as the compression decreases the efficiency will become less, the molecules farther apart and inflammation slower. Therefore the ignition must be advanced to obtain the dotted diagram, in which the firing line is practically parallel to CD.

Such a method of governing would materially increase the efficiency at half or partial load.

If, instead of moving the point of cutoff G toward B, leaving the mixture practically constant but taking in less gas as less load is required, we move the cutoff point G toward A, or to G' as in Fig. 5, and at the same time decrease the fuel per unit of air, the compression will be increased, rapidity of inflammation will remain practically constant, premature ignition will be improbable, the thermal efficiency should be practically as high as at full load and the initial pressure should be less, insuring smooth running at light loads.

If the fuel is diminished as the compression increases in such a manner that there will be just enough fuel at maximum compression to drive the engine idle and at the earliest cutoff to give the maximum mean effective pressure, the adjustment is complete. Should the fuel diminish faster than the compression increases, at the latest cutoff there would be a negative mean effective pressure of compression and the engine would stop. Between extremes, full and no load, the fuel compensation is automatic, securing complete and smokeless combustion.

In such a cycle the molecular arrangement is such that the speed of inflammation is practically constant for all loads, therefore the time of ignition need be advanced only with the engine speed to get a uniform angle to the firing line.

With such a cycle volumetric efficiency—

$$\left(\frac{\text{Volume of gas induced}}{\text{Volume of induction stroke}}\right)$$

which governs the theoretical compression can be maintained at unity, as the flexible denominator of the equation can be readily varied.

If the compression at two-thirds cutoff and maximum load is 90 lb. absolute, the maximum compression at no load would be practically 144 lb., yet so attenuated would be the mixture that premature ignition could not occur.

A standard carburetor would require no change in adjustment for full load, but would require a fuel opening that would vary inversely with the amount of air induced. The fuel valve and cutoff lever would be connected together and operated by the accelerator pedal or hand lever.

The Use of Concrete Machine Foundations in Germany*

Although concrete foundations have been successfully used for years under various kinds of machines, many are still prejudiced against them. Those maintaining that concrete is not the best material for heavy machine foundations argue as follows:

1. A brick foundation is more readily proportioned.
2. A brick foundation is immediately available for use.
3. The life of heavy driving machinery averages about 15 years, inasmuch as the advances made in machine construction make necessary the installation of heavier and more highly developed machinery in order to bring about increased output and more economical operation. Thus a stone foundation can be more easily broken up and the broken material used in the larger foundation made necessary by the change.

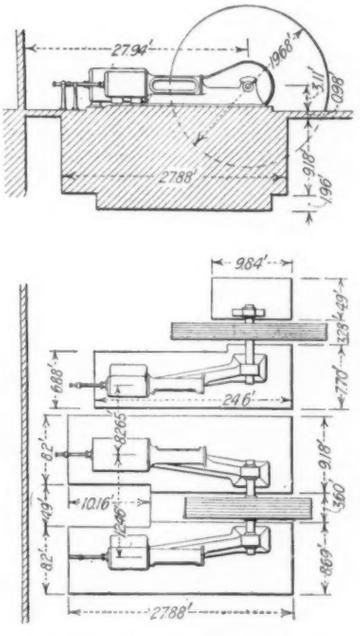


FIG. 1. THE OLD MACHINES TO BE REPLACED

4. Concrete foundations are difficult and expensive to break up, and the broken material is not only useless for further purposes, but entails expense in its removal.
5. Owing to the varieties of portland cement now in use, in order to produce a suitable quality of concrete capable of resisting heavy shocks, it often requires expensive experimenting.

In answer to these criticisms it might first be stated that if properly calculated, the proportions of concrete foundations are just as readily determined as brick, if not more so, owing to its uniform structure; and further, owing to the absence of joints, concrete has no weak points, thus making its strength at least equal to brickwork.

If properly attacked, concrete foundations are easy to break up, and the broken material can be utilized again. Used brick, with the expense of removing the mortar, is economical only in exceptional cases.

It is true that special knowledge and experience are necessary to produce a suitable quality of concrete from the commonly available building materials, such as portland cement, sand and gravel.

In the following the methods used in the construction of a foundation for a horizontal 2,000-hp. steam engine, erected in the Portland Cement Works of Heidelberg, Mannheim, will be described. The machine was installed to replace two other machines. The methods followed should help familiarize the reader with the essentials in this class of work and refute some of the common objections to concrete foundations.

In Fig. 1 the old machines destined to be replaced are shown. Their purpose was similar to that of the new one—driving the cement mills in which the cement clinker is pulverized. The new machine was installed to obtain a substantially larger output with a consequent reduction in steam

*Translated from "Zeitschrift des Vereines Deutscher Ingenieure."

consumption and attendance. Fig. 2 shows the new foundation, and from Fig. 3 it will be seen that a considerable part of the old foundations had to be removed, much of which was reutilized.

In breaking up the old foundations compressed-air drills were successfully operated. Holes were drilled at uniform distances in the side walls, and this enabled the removal of the old material in large lumps by the use of crowbars. With skilled labor available, familiar with explosive materials, it

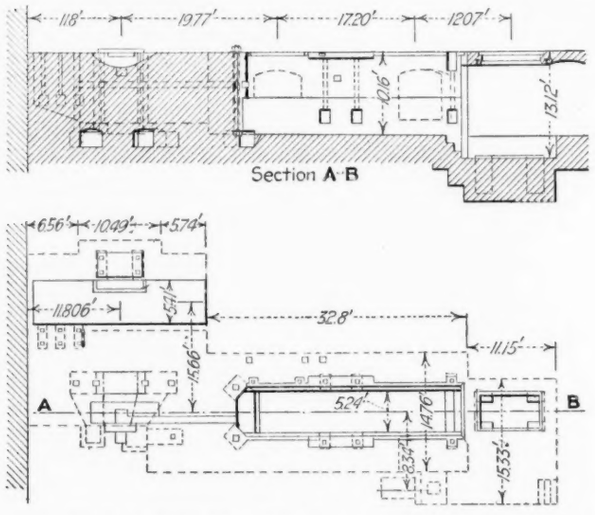


FIG. 2. FOUNDATION FOR THE NEW MACHINE

is possible to still further simplify the destruction of concrete foundations by light blasting. This is shown in Fig. 4. The crumbled material can be removed by hand and piled up just as handily as bricks. As the new foundations were not provided with any kind of retaining walls, it was necessary to erect temporary forms.

A mixture in the proportions of 1, 3, and 6 was determined upon for the concrete—that is, 1 lb. of portland cement, 3 lb. of sand and 6 lb. of gravel. It is readily appreciated that the best quality of concrete is obtained when the respective constituents are in closest bond. The mixing proportion must therefore be such as to avoid air spaces in the material, and this depends upon the quality of the sand used, its grain size and the gravel content. Proper proportions of coarser gravel and pebbles must be maintained.

In general the proper mixing proportion of sand and gravel is one weight unit of sand to two weight units of gravel. To this combination a determined proportion of cement is added. For foundation work the proportion of one to nine is generally recognized as most satisfactory, and this proportion was used in the foundation under discussion. To this mixture 3 parts of water was later added in a mixing

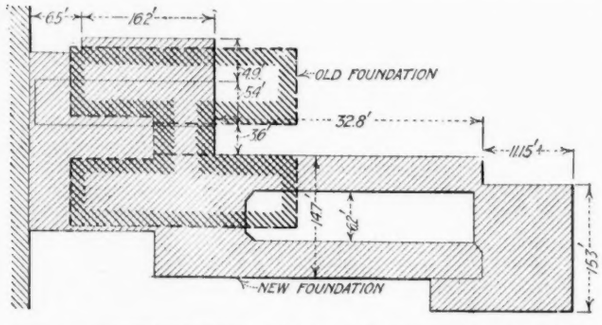


FIG. 3. SUPERIMPOSED PLANS OF THE FOUNDATIONS

machine. In hand mixing, three handlings with the shovel, before adding the water, are recommended, to secure an even distribution of the building materials.

Following this the ramming is just as important as the mixing. The concrete should be placed in layers to a height not exceeding 6 to 7 in. The thinner the layers the greater the strength. The use of broken stone, well supplied with water, often makes unnecessary ramming, inasmuch as the stone beds have a tendency to press together the concrete layers. The quality and quantity of the water used have a large influence on the quality of the resulting concrete. Likewise the rigidity of the forms is an important consideration. Unless the layers are added in fresh condition—that is, a fresh layer on top of a fresh unset layer—a sufficiently strong binding material must be used. Accordingly it is well to end a day's work with a layer of stone on top of which

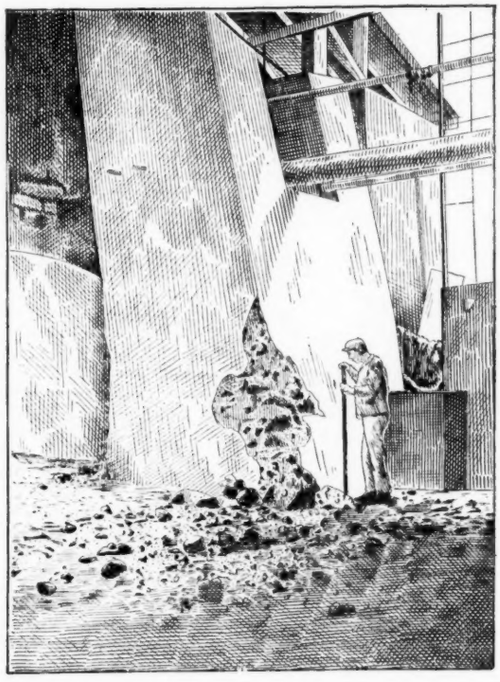


FIG. 4. BREAKING UP FOUNDATION BY BLASTING

a fresh layer of concrete should be added in the morning. The uneven surfaces of the stone give a good hold for the next layer of concrete and serve as reinforcement. It is advisable to sweep the contacting surfaces with a wet sharp steel broom and to spread on a thin layer of pure wet cement. One hundred parts of cement to 40 of water by weight is a good formula for this cement layer. Special care should be exercised in ramming the corners and other outer edges. The individual rammed surfaces should somewhat overlap each other. In Fig. 5 is shown the condition of the work when about completed. Large stones and concrete lumps can be embedded in the concrete in the manner shown.

A point worthy of special attention is the joining of the old foundation to the new. The adjoining side of the old

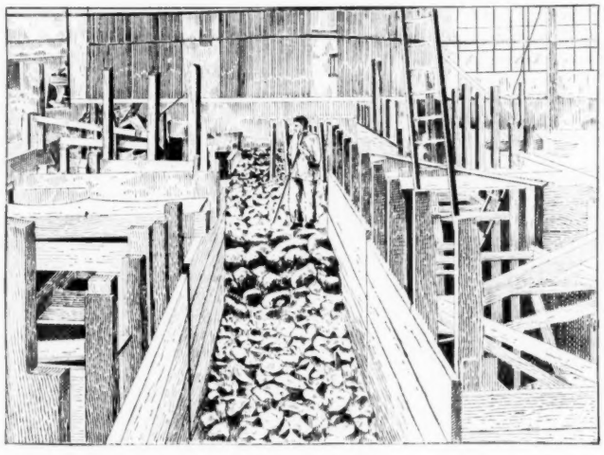


FIG. 5. PLACING BROKEN STONE IN THE FOUNDATION

foundation is drilled in several places, and heavy round iron bars are inserted in the drilled holes. These bars are surrounded with concrete and should extend up to about the middle of the new foundation. Besides this the whole surface of the old foundation is roughened, moistened and washed in with cement mortar. By taking these precautions it is

possible to join old and new concrete surfaces so that the whole is as strong as the respective parts.

In the new foundation here installed several of the carrying pillars had to be partly or entirely supported. This is shown in Fig. 5. Here, because of the exceptionally heavy bending stresses, iron reinforcing bars were used. In brick foundations square recesses like those in Fig. 2 are provided for the foundation bolts. The pull of the bolts is transferred to a larger area of the brick foundation through an iron plate on which the square bolt head bears. The use of bolts and plates is made necessary to overcome the weakening effect due to the brick joints. This is very much simplified in concrete foundations. It is only for the sake of precaution that the practice of anchoring by iron plates is followed, and the recesses are much more easily provided. As was done in this case, round instead of square recesses are left in the concrete. For this purpose a round pipe of the required diameter is embedded in the concrete which, when building high foundations, is carried up with the progress of the work. As in the brick foundations, it is advisable to later fill around the anchor bolts with a rich cement mixture to a height of 18 in. to 3¼ ft., according to the size and character of the machine. The anchor bolts should be roughened somewhat. In the present instance this means of fastening worked out successfully.

The complete construction of the foundation work described consumed 51 days, 31 of which were occupied in breaking up the old foundations and in effecting changes in the building such as location of conduits, etc.

Lightning Protection for Smoke-Stacks

At the annual meeting of the National Fire Protection Association, held at Chicago, May 9-11, the Committee on Signaling Systems submitted suggestions for protection against lightning. These included the installation for smoke-stacks, taking for example a stack 140 ft. high. The type and weight of conductors and other materials for use on stacks and the details of their installation are matters requiring in many cases expert investigation of the special conditions.

Two ground rods, the minimum number required for stacks of this type, are provided. A band of the conductor encircles the stack near the top, to which the air terminals and ground rods are connected.

The air terminals are spaced about 6 ft. apart around the periphery of the stack top and extend 18 in. above the top. They are of solid material provided with a thread on one end to be screwed into clamp connectors assembled on the band; the other end terminates in a point.

The air terminals are held in an upright position with fasteners set into the bricks as near the top of the stack as possible. The band encircling the stack is provided with fasteners not farther apart than 3 ft. and the ground rods have them at least every 5 ft. All parts of the equipment subject to the corrosive effects of the smoke are protected by a covering of lead $\frac{1}{16}$ in. thick.

Mechanical Soot Blowers*

The three principal boiler-room devices for conserving and utilizing what would otherwise be wasted heat are soot blowers, feed-water heaters and fuel economizers. Discussing these in the reverse order named, it may be stated that many large power plants and some of medium capacity are equipped with fuel economizers. Where a fairly steady load is maintained, where first cost is not prohibitive and where other important conditions are favorable, the use of the fuel economizer is in most instances profitable, affording a saving in fuel because of the heat transferred from the flue gases to the feed water.

There are conditions where economizers are more important than feed-water heaters. Comparatively few engineers or operators, however, are familiar with fuel economizers, owing to the fact that their use is not very general at present. The opposite is true of feed-water heaters, which conserve the heat units in the exhaust steam of the plant auxiliaries. Their use is universal, and the most ordinary firemen are more or less familiar with their value and operation. The fuel economizer extracts the heat directly from the products of combustion on their way to the stack, which for convenience, may be termed operating in the secondary stage. The feed-water heater effects its economy by subtracting heat from the exhaust steam, which has been primarily produced in the boiler and passed through the various engines, pumps and turbines, and this operation may be arbitrarily considered in the tertiary stage.

The last of the foregoing devices for conserving heat, the soot blower, differs materially from the other two. The soot blower gets in its good work in the beginning, or initial, stage of the process of generating steam power, or at the point of contact between the fire and the water. It does not catch any heat that is about to be lost, but rather, operates to secure the greatest possible efficiency in the initial production of steam. By keeping the boiler tubes free from soot and ashes so that the heat is readily transmitted to the water, a saving of from 3 to 15 per cent. in fuel may be secured.

According to Kent's "Mechanical Engineers' Pocketbook," soot has five times the heat-resisting power of asbestos, and only two substances—live geese feathers and loose wool—resist heat more than soot, the difference being very small. A material deposit of soot on boiler tubes has, therefore, the same effect on the water in the tubes, of a water-tube boiler, as the insulating material of an icebox on the ice; that is, it keeps the substance on the inside from absorbing heat rapidly from without.

It is the duty of the soot blower to keep the tubes of the boiler free from all deposit of soot and ashes, which are being steadily deposited from the products of combustion. As the steam that is being generated in the boiler is used for increasing the efficiency of steam generation, it may almost be stated that the boiler automatically keeps itself clean and efficient and may be likened to a self-lubricating steam engine or steam turbine which gives up a small amount of its power to force oil through its bearings to decrease the friction and thereby keep itself running smoothly with the least possible loss of energy due to friction.

While it is desirable to reduce coal consumption to the lowest possible point for any given load, it should also be remembered that it is sometimes much more important to increase the boiler capacity than it is to decrease the amount of coal consumed. This is a most important consideration in many older plants which have already reached capacity under the methods of hand-blowing, and often a plant may be made to do service for many months, and even years, by installing soot blowers, when without them it would be necessary to in some way increase the boiler capacity.

SAVINGS MADE BY SOOT BLOWERS

There are a great many items entering into the total efficiency and resulting economy secured by the use of the modern soot blower. The first has been mentioned and consists of the direct reduction in the amount of coal necessary for the generation of a given number of boiler horsepower-hours. The second important item is the saving in labor necessary to secure the desired results. The third is the saving in the amount of steam required to do the work, and the fourth is the lower interest and depreciation on the equipment required.

There are a number of less-direct benefits to be obtained by the use of mechanical soot blowers, which are sometimes lost sight of in estimating the possible increase in the general efficiency of the boiler room and power plant. The mechanical soot blower is easy to operate, offering little temptation to the fireman or water tender to shirk his periodic duty of cleaning the soot and ashes from the boiler tubes. The connections to the boiler of the latest and best soot blowers are made air-tight so that there is no leakage of cold air into the boiler either during or between the periods of soot blowing. The old hand methods sometimes introduced so much cold air into the boiler that the resultant loss more or less offset the increased efficiency gained by the comparatively clean tubes.

There is still another consideration of vital importance in the operation of the modern power plant—the perfecting of a simple but effective system that may be easily followed by the average fireman in keeping his boilers regularly cleaned. The modern soot blower is an actual encouragement to the conscientious fireman because he understands that he is securing from his boiler every possible unit of energy that may be expected from a carefully prepared and a carefully kept fire. The definite knowledge of the fireman that his boiler is clean from end to end and from top to bottom, so that the heat is readily absorbed by the entire exposed surface of the tubes and drums, is an incentive to handle his fires carefully, because he will have no excuse for not turning out all that is expected of the boiler and he will be sure that his efforts will not be partly wasted.

*Abstract of an article by P. V. Stephens, consulting engineer, New York City, which won first prize in the prize article contest conducted by the Diamond Power Specialty Co., Detroit, Mich.

The old hand and hose methods and some mechanical blowers require additional help in the boiler room for cleaning, but with the latest improved types of soot blower the cleaning of the tubes periodically every day and several times a day may be made a part of the routine duty of the fireman without adding materially to his duties, and in many instances his work is made more pleasant and efficient.

Many commercial tests have been made on the types of blowers, and also exhaustive laboratory tests have been made in engineering-school research laboratories, so that an abundance of evidence is available to guide the engineer in the selection of a soot blower. Some valuable progress has been made recently by soot-blower manufacturers, one of the most important departures being made in the production of the "venturi," or expansion, nozzle by which the initial velocity of the steam leaving the nozzle is increased over 200 per cent. This reduces the cost of installation and also the amount of steam required in blowing the soot. The high velocity insures thorough and quick cleaning of all parts of the boiler, saving time as well as steam.

Mechanical soot blowers have come to stay, and old plants as well as new can get the benefits of them. The plant that is operating without soot blowers is not only behind the times, but is losing money.

Industrial Deaths Reduced in California

The Industrial Accident Commission of California reports the number of deaths in the industries of that state during the year 1915 as 533, compared with 691 in 1914—a reduction of nearly 23 per cent. The following table shows the reductions in the death list by occupations (the word "Service" includes employees of men in the professions, as well as those engaged in hotel service, apartment houses, restaurants, domestic servants and amusement or entertainment employees):

	1914	1915	Decrease Per cent.
Agriculture	62	55	11.3
Construction	115	78	32.2
Extraction (mining and quarrying)	86	71	17.4
Manufacturing	121	99	18.2
Service	24	25	...
Trades	24	20	16.7
Transportation and public utilities	239	172	28.0
Unknown	20	13	35.0
Total	691	533	22.9

The effective work in behalf of "Safety First" has been accomplished as a result of cordial support from employers and employees, the public generally, and the press of California. That this reduction comes as the result of careful planning is shown by the decrease in the main industries of the state, except "Service," where the record shows an increase of one death in 1915 over 1914.

Diesel Engine Management

Discussing Diesel engines in a paper before the Institution of Naval Architects, Lieut.-Commander W. P. Sillince, R. N., pointed out a few of the details which have given trouble in operation and need special care and attention.

One of the principal difficulties appears to lie in the selection of proper materials for cylinders, pistons and cylinder covers. Many intricate and costly castings of iron have failed owing to stress, irregular expansion or inadequate jacket cooling. Cast steel has been tried and has failed; semi-steel (cast iron containing a percentage of cast or wrought steel) is but little better; manganese bronze is being tried in some instances for covers, but its success is doubtful. The best material so far found is a carefully selected grade of cast iron having a close grain, a high tensile strength and a small coefficient of heat expansion, but which is sufficiently fluid to completely fill the mold without undue internal stress on solidification. It is doubtful whether the annealing of cast iron is of any real benefit; slow solidification and avoidance of chilling seem preferable.

Frequent sources of trouble, which generally are located before the engine leaves the shop, are directly traceable to inaccuracies of workmanship. Holes and bores which should be circular and parallel and made to certain dimensions are often not so. Efforts made to correct these inaccuracies of manufacture lead to still worse troubles; valves and spindles are bent and may seize; the valves remain open when they should be closed, and when in the closed position they may leak. This applies particularly to fuel valves, fuel pump plungers and air-compressor valves.

The most frequent source of trouble at starting is loss of air, and the obvious remedy is an efficient means of economizing its use, a sufficient supply and adequate auxiliary capacity for replenishment.

Sluggish starting may be due to inefficient compression, owing to leaky piston rings, leaky valves, wearing down of the bearings or failure of the fuel pumps to pick up their fuel supply promptly, due to air pockets, leaky valves or incorrect setting as regards quantities. If the starting valves are not operating as they should, the engine may fail to start, and it is often necessary to wait until the air supply is replenished before a further attempt is possible.

One of the most serious troubles is that which may arise from the introduction into the working cylinders of fuel before the proper time. In such cases the engine preignites, with consequent increase of temperature and stress during combustion. This may result in violent knocking, overheating and stressing of the parts. The most frequent cause of this trouble is stuck, sluggish or inoperative fuel valves, due either to bad alignment or to seizure in the glands. A further cause of misfiring is the cooling of the cylinders due to rapid expansion of the high-pressure starting air, the admission of which may be frequently repeated in cases of faulty starting, and the corresponding admissions of fuel may be overlooked and cause disaster when the ignition does occur.

Another but controllable cause is the abuse of priming—that is, filling the fuel delivery pipe with fuel. So long as adequate precautions are taken the process is safe, but if, owing to a fuel valve being open or subsequently lifted off its seat, or the bypass valve being left closed, fuel enters the cylinder and is allowed to lie on the piston crown, accident from preignition may result.

Air compressors in the past have given considerable trouble, owing to excessive lubrication, inadequate cooling during compression and between stages, ineffective drainage and insufficient relief. These difficulties have been almost entirely surmounted, and the latest compressors run for months with only moderate attention.

ENGINEERING AFFAIRS

Phœnix Association No. 24, N. A. S. E., held its annual smoker on Saturday, Apr. 22, at German Masonic Temple, Fifteenth St., New York City. There was the usual big attendance, a first-class entertainment by the "Bunch" and a plentiful supply of refreshments.

New York, No. 33, of the Marine Engineers' Beneficial Association held its annual banquet at the Broadway Central Hotel, on Tuesday May 2. Covers were laid for 125 members and guests. There was an enjoyable entertainment, and many prominent persons in the marine line gave addresses.

The Brooklyn Engineers' Club, of Brooklyn, N. Y., held its annual smoker on Tuesday evening, Apr. 25, at the Imperial Hotel. The large banquet hall was filled to capacity. The New York Engineers' "Bunch" furnished an excellent entertainment, and good things to eat, drink and smoke were generously served.

The New England States Association, N. A. S. E. will hold its annual convention and mechanical exhibition in Fall River, Mass., on July 12, 13 and 14. The mechanical exhibition will be held in the State Armory. The resources of all Fall River will be devoted to making the convention, the power show and the stay of the visitors an enjoyable and successful event. Fall River is one of the leading textile centers of the world. One hundred and twelve mills, employing 35,000 operatives, turn out more than a billion yards of cloth a year. The capital invested in cotton manufacture alone is $34,000,000. The local committee consists of John A. Graham, chairman; John T. Maloney, secretary; Thomas F. Harkins, Eli Howarth, Michael H. Harrington, Richard Keighley, all of Fall River or of the Fall River Chamber of Commerce.

Chicago Engineers Inaugurate Preparedness Campaign—A group of prominent engineers and contractors of Chicago and vicinity have coöperated in forming a Joint Committee on Military Engineering. The founders are members of the leading engineering and contracting organizations of Chicago, including the local branches of the national engineering societies. The purposes are to further military preparedness among engineers, contractors and their associates by courses of lectures, assigned reading, studies and practical instruction in military engineering, assisting engineers to qualify as officers in the National Reserve Corps of Civilian Engineers, urging enlistment in and support for engineer troops of the National Guard and such other organizations as the Government may create, furthering instruction in military